CALIFORNIA PORTABLE CLASSROOMS STUDY
PHASE I: MAILED SURVEY

FINAL REPORT, VOLUME I
CONTRACT NO. 00-317

PREPARED FOR:

California Air Resources Board
Research Division
1001 I Street
Sacramento, CA 95814

and

California Department of Health Services
Environmental Health Laboratory
Indoor Air Quality Section
2151 Berkeley Way
Berkeley, CA 94704

Prepared by:

Roy Whitmore
Andy Clayton
Michael Phillips
Gerry Akland

RTI International
3040 Cornwallis Road
Research Triangle Park, NC   27709

May 2003

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ACKNOWLEDGEMENTS

We gratefully acknowledge the participation of Annette Green and Brenda Gurley of RTI International, in data analysis and preparation of this report. We also acknowledge the cooperation of the superintendents of the school districts and principals of the schools for approving the participation of the teachers and facilities managers, and the teachers and facility managers for diligently providing the requested information. We also thank Peggy Jenkins, Tom Phillips, and Tracy Hysong of ARB, and Jed Waldman and Kai-shen Liu of DHS for their guidance, involvement and support for this project. This draft report is submitted in partial fulfillment of Contract Number 00-317, under the sponsorship of the California Air Resources Board.

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ABSTRACT

The purpose of this California Portable Classrooms Study was to assess environmental conditions in California's portable classrooms. This report documents results from a mailed survey to a probability sample of all public California K-12 schools with at least one portable classroom. Two questionnaires, a Facilities Questionnaire and a Teacher Questionnaire, and passive formaldehyde samplers were mailed to the sample of schools selected to participate in the survey. This report describes the sample design, the survey instruments, the data collection process, the data analysis procedures, and the results that show and compare the major characteristics of the populations of eligible public schools as well as portable and traditional classrooms. Response rates were between 40 and 45% for school-level responses. However, for schools that responded, response rates at the classroom-level were about 95% for teacher questionnaires and for formaldehyde monitoring. The population of schools with one or more portable classrooms is estimated to consist of about 6,900 schools, with a total of about 145,000 traditional classrooms and about 85,000 portable classrooms.

Key results include:

(a) characterization of the target population:
- the majority of the schools are in the suburbs (73.8%); only about 9% are in the rural areas
- nearly 60% of the schools were elementary; the others were split evenly between middle and high schools.

(b) construction:
- over half (54.4%) of the schools are estimated to have 10 or fewer portable classrooms; only 4.4% are estimated to have more than 30 portable classrooms
- over half of the portable classrooms (55.3%) are 10 years old or less; only 12.4% of the traditional classrooms are that new
- about 29% of the schools are less than 30 years old.

(c) complaints/symptoms:
- 52% of the facility managers received some environmental related complaints in the previous school year (2000-2001)
- most common complaints in portable classrooms, ranked in order of prevalence, were: roof leaks, air quality/odor, temperature, plumbing leaks, mold, and noise, respectively
- most common complaints for traditional classrooms were: roof leaks, temperature, air quality/odor, plumbing leaks, mold and noise, respectively.
- most problems and complaints, except plumbing leaks, were more prevalent in portable classrooms.

(d) formaldehyde:
- a number of factors appear to be associated with formaldehyde levels in both types of classrooms, including: age of classroom, geographic region, season of the year, age of carpet, and age of new flooring.

- formaldehyde levels were higher in the portable classrooms than in the traditional classrooms (mean of 32 vs. 24 ppb; median of 27 versus 20 ppb).
- fifty percent of the portable classrooms were estimated to exceed 27 ppb, the Draft 8-hour Indoor Reference Exposure Level (REL) (Broadwin, 2000; OEHHA, 2000), as compared to 29% of the traditional classrooms. Four percent of the portables and 0.4% of the traditional classrooms had average concentrations above 76 ppb, the 1-hour California Acute REL for formaldehyde.

Results from this survey suggest that there are major issues associated with environmental conditions in California K-12 schools that deserve appropriate attention. Furthermore the environmental factors, complaints, and health symptoms reported by the teachers and facility managers in the sampled schools are often different between the traditional and portable classrooms. Measured levels of formaldehyde are significantly higher in the portable classrooms than in the traditional classrooms. However, more extensive monitoring and classroom assessment are required before meaningful recommendations can be formulated to improve the environmental conditions reported to exist in the California public classrooms. This information is forthcoming in the Phase II study that is being conducted in the school year 2001-2002.

EXECUTIVE SUMMARY

BACKGROUND

There are many reasons to study the school indoor environment. While in school buildings, the children and staff may be exposed to a number of chemicals and biological materials. Children are also more likely to suffer health consequences from indoor pollution. School buildings by design are densely populated, making the task of maintaining an acceptable indoor air quality much more difficult than in many other types of facilities.

Concerns over indoor environmental quality in California's schools have risen recently as the demand for classrooms has resulted in increased reliance on portable classrooms. Portable classrooms are of special concern—inadequate, noisy ventilation systems and mold problems have been reported in portable classrooms. Also, manufactured buildings may emit many chemicals from the particleboard, plywood, fiberglass, carpets, glues and other materials used in their construction, especially formaldehyde. Formaldehyde is an irritant and probable human carcinogen. The California Air Resources Board (ARB, 1992, 1997) has identified it as a Toxic Air Contaminant, and the Office of Environmental Health Hazard Assessment (OEHHA, 2002) has listed it as a carcinogen requiring Proposition 65 warnings.

To address increasing concerns about portable classrooms, the California Portable Classrooms Study (PCS) was requested by Governor Davis and mandated by the State Legislature. It was endorsed by the Superintendent of Public Instruction, Ms. Delaine Eastin. The Legislative mandate with milestones and requirements is specified in AB 2872, Shelley, and California Health and Safety Code (HSC) Section 39619.6. The PCS is being conducted in response to this legislative mandate. The final report to the Legislature is due by June 30, 2002. The findings from the PCS will form part of the basis for recommendations that ARB and DHS must make to the Legislature regarding ways to "…remedy and prevent unhealthful conditions found in portable classrooms…" (AB 2872).

Until this study, there has not been a systematic or comprehensive statewide survey or measurement of indoor environmental conditions in California public schools. This study consists of two major parts. Phase I is a mailed survey in which questionnaires and passive formaldehyde monitors were sent to a probability sample of all public schools with at least one portable classroom, and Phase II is a monitoring study of environmental conditions in a smaller sample of classrooms in California.

Once the PCS is completed, results will be used by ARB, DHS and interested stakeholders to assess the potential for adverse health impacts from environmental conditions and toxic pollutants that may be present in portable classrooms and, where necessary, to identify and implement effective actions that can be taken to remedy or prevent any unhealthful conditions found. This report documents results only from the first phase of the study, the mailed survey. This report describes the sampling design, the survey instruments, the data collection process, the data analysis procedures and programs, and the results that show and compare the major characteristics of the populations of eligible schools as well as portable and traditional classrooms.

METHODS

ARB and DHS held public workshops and meetings across the state to receive input on study design from the public, industry, and government agencies. The information obtained proved valuable in recruiting schools to participate in the study and in designing the questionnaires.

Two questionnaires, a Facilities Questionnaire and a Teacher Questionnaire, were collaboratively created with CA Air Resources Board (ARB) and CA Department of Health Services (DHS) for this study. Materials developed to describe and convey the study objectives and procedures to the school superintendents, school districts and schools include: a study brochure, introductory letters to superintendents and principals, and introductory letters to principals, teachers, facility managers, and study coordinators. As part of this material, a web site was created to facilitate access by schools and districts to study materials.

The sample of schools selected for the Phase I mailed survey is statistically representative of all California public schools that had portable classrooms in the Spring of 2001 because the sample was randomly selected from all schools on the California Public Schools Directory 2000. DHS staff selected an initial systematic sample of 1,216 schools. They conducted a preliminary survey which determined that 177 (14.6%) of these schools were ineligible for the study because they had no portable classrooms. A random sample of 1,000 of the remaining 1,039 schools was selected for the mail survey, but 48 (4.8%) of them were determined to also be ineligible. Therefore, about 19.4% (14.6% + 4.8%) of California's public schools had no portable classrooms in the Spring of 2001 and are not represented by this study.

The Phase I study was a mail survey which was conducted in the spring of 2001 with data receipt continuing through the summer of 2001. It was based on a probability sample of California public schools (and classrooms) having one or more portable classrooms. Facility managers provided school-level data (n = 384) and classroom-level data (n=1,133), via a Facilities Questionnaire (FQ). Teachers provided additional classroom level data (n = 1,181), via a Teacher Questionnaire (TQ). The classroom data were collected for three classrooms, usually two portable classrooms and one traditional classroom at each school. For a subsample of the classrooms, passive formaldehyde samplers (small glass tubes) were placed in the classrooms for approximately 10 days to collect indoor air samples that were analyzed to determine formaldehyde concentration levels (n = 911).

For quality control purposes, several formaldehyde samplers were pre-tested, and protocols were developed to optimize the limit of detection and the precision of the samplers in the field. Fifteen percent of the schools received a field blank (i.e., the tube was not to be opened during the sampling period) and 30% received a duplicate monitoring tube.[1] The duplicate tube was to be handled exactly like the original sampling tube (i.e., uncap one end to allow air to flow into the tube and hang it in the designated classroom for 7 to 10 days), except that it was to be positioned next to the primary sampling tube. Analysis of the laboratory blanks resulted in an

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[1] Because each school had three sample classrooms, the classroom-level QC sampling rates were 5% for blanks and 10% for duplicates, or 15% overall.

estimated detection limit of 6 ppb. Analysis of the duplicate samples verified that analytical precision was good (10% to 15% median RSD).

The formaldehyde samplers and lab analyses were provided by Air Quality Research. The 1,181 completed Teacher Questionnaires and the 384 completed Facilities Questionnaires were scanned and compiled into Excel spreadsheets. Two SAS[2] files were then prepared for use in data analysis—a school-level file and a classroom-level file. School-level sampling weights and classroom-level sampling weights, each adjusted for nonresponse, were included on the respective SAS files.

Statistical estimates of population parameters such as means and proportions were carried out using weighted data analysis techniques. SUDAAN software (RTI, 2001) was used to generate the estimates and to properly account for features of the sampling design in the estimation of precision of such estimates (e.g., confidence intervals). Approximate t-tests were employed to compare portable and traditional classrooms with respect to formaldehyde levels. Wald chi-square tests were used to test for associations and Wald F tests were used to test for significance in analysis of variance models (RTI, 2001).

RESULTS

The target population of K-12 public schools with one or more portables is estimated to consist of 230,000 classrooms, 37.1% of which are estimated to be portable classrooms. (Estimates based on the preliminary sample were 225,000 classrooms, with 36% portable.) Response rates between 40 and 45% (for questionnaires and formaldehyde monitoring) were characteristic of school level responses. However, for schools that responded, response rates at the classroom level were about 95% for the teacher questionnaire and school handling of the formaldehyde tubes. This response rate indicates the overwhelming interest of the participating schools in complying with the survey requirements and supplying responses to the requested information.

Significant differences in the building characteristics, environmental complaints, and teacher symptoms were found in portable classrooms compared to traditional classrooms. Portable classrooms were more prevalent for elementary schools than for middle or high schools. When compared with traditional classrooms, portables were more likely to be newer in age and have more carpet, more tackable wallboard, more exterior doors, more opening of windows, and more air conditioning with thermostat control. Teachers in traditional classrooms have a strong preference for traditional classrooms, but most teachers in portable classrooms do not prefer to be in traditional classrooms. Most reported problems and complaints, except plumbing leaks, were more prevalent in portable classrooms (i.e., roof leaks, air quality/odor, mold, temperature, and noise).

Valid indoor-air formaldehyde concentration data were obtained from 911 classrooms (644 portable and 267 traditional). Concentrations are based on ~10-day passive monitoring measures. Only about 3% of the classrooms had non-detectable concentration levels, i.e., less than 6 ppb. Hence, nearly all of the classrooms had indoor formaldehyde levels greater than

[2] SAS is the registered trademark of SAS Institute, Inc., Cary, NC.

typical outdoor levels in California (3 ppb), the Proposition 65 notification level equivalent for air (1.3 ppb), and the OEHHA Chronic Reference Exposure Level (REL) of 2.4 ppb for long-term exposure (ARB, 2001; OEHHA, 2002; OEHHA, 2001). The latter level is based on protecting sensitive individuals from nasal and eye irritation and nasal/upper airway injury.

The short-term health-based guidelines for formaldehyde in California are 27 ppb (Draft 8-hour Indoor REL) and 76 ppb (1-hour level Acute REL) (Broadwin, 2000; OEHHA, 1999). These guidelines are designed to protect sensitive individuals against eye irritation and effects on the respiratory and immune systems. The 10-day average levels of formaldehyde are designed as screening estimates, and do not directly compare to standards and guidelines based on shorter time periods. However, because they are longer-term averages, they are probably conservative estimates of 1- and 8-hour levels of formaldehyde reached in classrooms.

As can be seen in the following table and figure, the formaldehyde concentrations were significantly higher for portable classrooms than for traditional classrooms. For example, 50% of the portables had concentrations above 27 ppb, whereas only 29% of the traditional classrooms were higher than 27 ppb. Also, 4% of the portables had concentrations above 76 ppb, whereas only 0.4% of the traditional classrooms were higher than 76 ppb. The mean levels were 32 ppb in portables and 24 ppb in traditional classrooms and 27 ppb across all classrooms.

Table ES-1. Formaldehyde Concentrations in All, Portable, and Traditional Classrooms

	All Rooms	Portable Classrooms	Traditional Classrooms
% of Rooms > 27 ppb	36.9	50.3	29.0
% of Rooms > 76 ppb	1.8	4.0	0.4

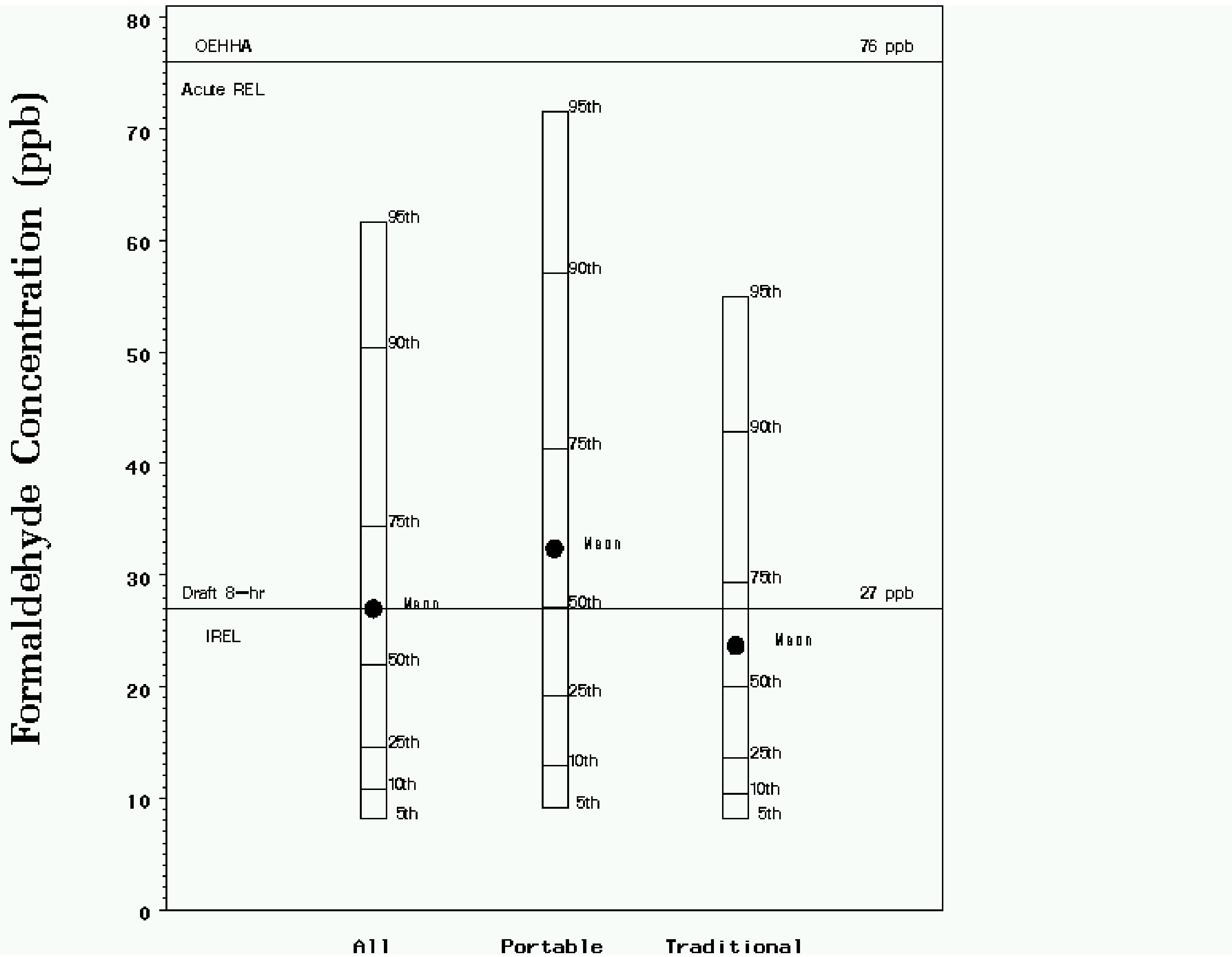
A number of factors appear to be significantly ($p < 0.05$) associated with high formaldehyde levels in portable classrooms. These include:

- Classroom age—higher formaldehyde in newer classrooms
- Date of formaldehyde sample—higher formaldehyde levels in warmer season
- Presence of pressed wood cabinets
- Chemical present in room
- Larger classroom size

Factors which appear to be significantly ($p < 0.05$) associated with higher formaldehyde levels in traditional classrooms include:

- Classroom age
- Geographic region—higher levels in the southern region
- Date of formaldehyde sample—higher levels in the summer months
- New flooring—higher levels in rooms with new flooring
- Odor—higher levels in rooms with new furnishing odor
- School construction this year
- Vinyl tackable wallboard
- New pressed wood last year.

Figure ES-1. Estimated Distributions of 10-Day Formaldehyde Concentrations in California Classrooms



[1]76 ppb is the OEHHA Acute REL.
[2]27 ppb is the draft 8-hour Indoor REL.

CONCLUSIONS

This is the largest, most comprehensive study of indoor environmental quality in California schools to date. The mail survey was successful in providing school-level and classroom-level environmental information regarding California public schools over two seasons and by school type (elementary, middle, and high school). Once the schools granted the teachers and facility managers permission to participate (and supplied them with the survey questionnaires and formaldehyde samplers), overall participation exceeded 90%. However, about half of the selected schools elected not to participate, in part due to Spring breaks, end-of-year testing, competing studies and surveys, and other factors.

Key results include:

1. The target population was estimated to be about 230,000 classrooms, of which about 37% are estimated to be portable classrooms;
2. Complaints to facility managers are fairly common; more than 50% of the facility managers received a school complaint last year; many of these complaints may be interrelated, e.g., noise, temperature, mold, and air quality/odor are all affected by ventilation;
3. Most types of environmental complaints were more prevalent for portable classrooms;
4. Higher formaldehyde levels occurred in the southern half of the state and in the warmer months sampled (possibly because formaldehyde emissions increase under higher temperature and humidity levels);
5. Higher formaldehyde levels were found in those rooms where teachers reported frequent nasal problems;
6. Higher formaldehyde levels were found in those rooms with new carpet in the past year and with those rooms with new flooring in the past year;
7. Higher formaldehyde levels were found in larger portable classrooms (>1100 square feet) than in smaller portable classrooms; and
8. Portable classrooms tend to have higher formaldehyde levels than traditional classrooms in the newest age group (0 to 3 years); for the other age groups, there was little difference between the two types of classrooms.

In addition to the above factors and perceptions, measurements of formaldehyde in the classrooms indicated that formaldehyde levels were indeed higher in the portable classrooms than in the traditional classrooms. The long-term (7-10 day) measurements at 4.0% of the portables and 0.4% of the traditional classrooms had values above 76 ppb, the CA acute REL (reference exposure level) for one-hour exposure. This means that sensitive individuals might experience symptoms at exposures above that level.

From the above list of significant results, it is clear that there are differences in environmental factors and perceptions between portable and traditional classrooms. However, further analyses are needed to identify which of the interrelated factors are most significant in determining indoor sources and measures to be taken to reduce these sources. Phase II will provide additional data to assistant in these analyses.

1. INTRODUCTION

The California Air Resources Board (ARB) and the California Department of Health Services (DHS) provided funding to address indoor environmental concerns resulting from use of portable classrooms. These concerns have included problems associated with contamination from formaldehyde and other VOCs, carbon monoxide (CO) and other combustion pollutants, microbial growth, odors, and excessive temperature and noise. Problems have been attributed to inadequate or deferred maintenance, poorly designed and noisy heating, ventilating and air conditioning (HVAC) systems, and the use of pollutant-emitting materials, products, or equipment in or near buildings. Health symptoms reported in schools are similar to those which are reported in “sick buildings.” Of noted concern are asthma-like symptoms, since asthma is one of the upward trending respiratory diseases in the U.S.

The purpose of this study is to assess environmental conditions in California’s portable classrooms. The results will be used by ARB, DHS and other stakeholders to assess the potential for adverse health impacts from environmental conditions and toxic pollutants that may be present in portable classrooms, and identify effective actions that can be taken to remedy or prevent any unhealthful conditions found.

To generate the required data, a study was conducted consisting of three parts—a mailed survey, a pilot field study of the proposed methodology, and the environmental assessment field study of a sample of portable and traditional classrooms. Results from each of these aspects of the study will be presented in a separate project report. This is the first of these reports, focused on documenting the materials and methods and presenting the results of Phase I, the mail survey.

1.1 Background

There are many reasons to study the school indoor environment. Children in California spend, on average, about 5.5 hours/school day. A large percentage of that time is spent indoors (Robinson and Thomas, 1991; Jenkins et al., 1992; Phillips et al, 1991). Teachers and other school staff typically spend even more time in school buildings. While in these buildings, the children and staff may be exposed to a number of chemicals and biological materials. For example, children are more likely to suffer the consequences of indoor pollution. School buildings by design are densely populated, making the task of maintaining an acceptable indoor air quality much more difficult than in many other types of facilities. Yet there have been few, if any, studies of the effects of the school environment on the learning process.

As noted above, problems have been associated with inadequate or deferred maintenance, HVAC problems, and the use of pollutant-emitting materials, products, or equipment in or near buildings (Bayer, et al., 1991). Concerns over indoor environmental quality in California’s schools have risen recently as the demand for classrooms has resulted in use of portable classrooms. Portable classrooms are usually constructed with materials and HVAC systems different from those used in the traditional classrooms. Manufactured buildings emit hundreds of chemicals which are emitted from the particle board, plywood, fiberglass, carpets, glues and other materials used in the construction. Adding to potential problems and environmental factors influencing the physical classroom are the specific activities which may be ongoing during the day that could add to already significant “background” concentrations. For example, VOC emissions of arts and crafts can add to levels of 1,1,1-trichloroethylene, toluene, xylenes, and formaldehyde.

Limited information indicates that some indoor environmental conditions in portable classrooms potentially put children at risk of serious health impacts. It has been reported that 63% of a total of 144 school districts responding to a California survey have experienced health complaints which may be associated with the classroom environment. These problems were attributed to moisture, fungal contamination, poor ventilation, and maintenance issues (CASH, 1999). Until the present study, referred to as the California Portable Classroom Study (PCS), there has not been a systematic or comprehensive statewide survey or measurement of indoor environmental conditions in California schools. California currently requires warning labels on art supplies used in schools, and prohibits those supplies that contain certain toxins (California Education Code ? 32060-32066. (See references for relevant web sites.)

1.2 Objectives of Phase I Report

Specific objectives of this report are the following:

- To document the Phase I sampling design and associated sampling weights
- To describe the survey instruments and data collection process
- To describe the formaldehyde sampling and analysis procedures
- To document the data processing, including adjustments to sampling weights
- To document the data analysis procedures and programs
- To present data analysis results that show the major characteristics of the populations of eligible schools and classrooms, including the formaldehyde concentration levels, and to compare portable and traditional classrooms.

Section 2 of this report discusses the materials and methods and Section 3 presents the data analysis results. Section 4 provides a brief discussion of the results. Section 5 contains our summary and conclusions; Section 6 contains our and recommendations. References can be found in Section 7.

2. MATERIALS AND METHODS

2.1 Questionnaire Development

Two questionnaires were created, edited, and formatted as Teleform or "scannable" instruments: a Facilities Questionnaire (FQ) and a Teacher Questionnaire (TQ). Copies of each are provided in Appendix A. ARB and DHS supplied the content for the two questionnaires, primarily a reconstruction of relevant questions asked in other indoor air quality surveys. Substantial changes included editing the instruments to address conditions in schools rather than commercial buildings, categorizing items under common headings, and adding columns for the three sampled classrooms. Formatting the questionnaires required the services of Teleform programmers. Programmers added instructions for marking boxes, bar codes, and boundary markers to the questionnaires. Programmers were also responsible for testing the two instruments before they could be used in the field. Testing the questionnaires involved printing copies of the questionnaires, "marking up" the questionnaires, and using the scanning equipment to "read" the marked up questionnaires. The latter was a quality assurance procedure to determine if the scanning equipment and Teleform program were interpreting the data properly.

2.2 Development of Introductory Letters and Other Survey Materials

Letters, postcards, a brochure, and all the survey instructions were developed to accompany the questionnaires. Draft versions of each letter and other materials were sent to ARB and DHS for review. Additional iterations were made until all parties were satisfied with the final version. Final versions of all materials, including the two questionnaires, were approved by RTI's Institutional Review Board before the mailings were conducted. Copies of all the supporting survey materials also are provided in Appendix A.

2.2.1 Introductory Letters to Superintendents and Principals

Introductory letters, often called "lead letters", were developed to make the superintendents and school principals aware of the research study and to encourage their support. A letterhead was designed that depicted the study as a joint project of ARB and DHS. The letters were drafted by a survey specialist with expertise regarding mail surveys. Both letters strongly encouraged support by stating that the survey was mandated by the state of California and that the survey was endorsed by the California Superintendent of Public Instruction, Ms. Delaine Eastin. Participating districts and schools were assured that survey results would remain confidential. The school superintendents were given the opportunity to request the survey results for schools that participated from their district. A web site link was developed to make it easier for superintendents and other district staff to review the survey materials.

Superintendent and principal names were available from the California Public School Directory 2000. However, only the superintendent names were used for the mailing because the year-old principal names were not considered current enough. The lack of principal names may have had an effect on the manner in which letters and other survey materials were delivered to school principals—for example, secretaries may be more likely to pass along letters or packages that are addressed to the principal by name. This lack of principal names also restricted our access to the principals during the call back to non-responding schools, as discussed below.

2.2.2 Postcards to Superintendents and Principals

Postcards were created on colored stock and inserted in the superintendent "lead letter" mailings. Postcards were addressed to superintendents for two reasons: to inform the superintendents of the schools in their district that would be contacted and to give the superintendents the opportunity to request the formaldehyde results for schools in their district.

Principals received postcards too, but they were included in the main school package. The purpose of principal's postcard was also twofold: to determine if the schools intended to participate, and to obtain the name and contact information of the person at each school responsible for coordinating the study.

2.2.3 Introductory Letters to Principals, Teachers, Facility Managers, and Study Coordinators

Within the main survey package, introductory letters were enclosed in white envelopes addressed to teachers, facility managers, and study coordinators. The principal letters were placed on top of the survey envelopes because the package was addressed to the principal.

The principal's letter reiterated the importance of the study, asked that the principal assign a study coordinator to facilitate distribution and collection of study materials, and asked the principal to return the enclosed postcard or fax transmittal sheet identifying that person. In the first batch of letters mailed in early April (Wave 1), the letters said that the study was voluntary, but that provision was edited out of the Wave 2 letters (mailed the end of April) to improve response rates.

Teachers were sent letters explaining the purpose for the study and asking them to participate by completing and returning the enclosed questionnaire. Their letters did say that their participation was voluntary.

Facility manager letters were directed to the school or district staff responsible for maintenance in the school and portable classrooms. It was not possible to determine in advance if the facility manager was at the school site or at the school's district office. The letters explained the importance of the study, and made two requests: to complete and return the enclosed Facilities Questionnaire, and to assist the study coordinator as he/she selected classrooms and hung the formaldehyde tubes. Moreover, the letter stated that the facility manager's participation was voluntary.

Study Coordinator letters were addressed to the person assigned by the school principal to coordinate all study activities at the school. The letter also explained the importance of the study, and suggested the most efficient method to go about distributing and completing the study materials.

2.2.4 Instructions for Selecting Classrooms, Formaldehyde Tube Placement, and a Procedure Checklist

Simplifying the instructions for all the survey materials proved to be a difficult task. The methods and materials involved in the survey were foreign to most school staff. It was necessary to break procedures down into steps and to clarify without adding too many lengthy instructions. Detailed instructions were successfully developed for the study coordinator to carry out all the required survey tasks in an efficient manner.

The study coordinator was responsible for following the instructions outlined in the procedure checklist by distributing questionnaires, selecting classrooms, and placing (or hanging) the formaldehyde tubes.

Instructions for randomly selecting classrooms. RTI's Project Director, a senior statistician, developed the method for randomly selecting traditional and portable classrooms in the schools. The instructions included definitions (for study purposes) of classrooms, portable classrooms, and traditional classrooms. The preliminary steps were to obtain a site map and number the portable and traditional classrooms with the enclosed green and red leaded pencils. Once the classrooms were numbered on the site map, the numbers of portable and traditional classrooms were counted. These counts were then used to reference the first column of the classroom selection table at the end of the instructions. The study coordinator was asked to select classrooms by using the room numbers in the adjacent columns of the table. If possible, two portable classrooms and one traditional classroom were selected.

Instructions for formaldehyde tube placement. Instructions were developed to simplify the process of labeling the formaldehyde tubes, hanging them properly in the correct classrooms, and documenting the times and dates the tubes were hung and retrieved on the Analysis Request Form. The instructions were clarified to make sure the reader understood that the classrooms associated with the questionnaires were the same classrooms that received formaldehyde tubes.

Procedure checklist. A step-by-step checklist for the study coordinator provided details on distributing and completing the survey materials in the most efficient manner. This checklist, called the "study coordinator checklist", helped the study coordinator follow the other instructions in the right chronological order. Separate checklists were developed for schools that did and did not receive formaldehyde tubes.

2.2.5 Study Brochure

A study brochure was developed to emphasize the importance of the mail survey and to promote participation. The brochure was developed in a question and answer format for the most commonly asked questions about the survey. For example, participants may have asked "why was my school chosen, how long will it take, or how will the study benefit me and my school?" These types of questions are all answered in detail. The study web site also was cited in the brochure, http://www.arb.ca.gov/research/indoor/pcs/pcs.htm.

The brochure's colors, logos, and formatting were developed by a graphic artist. The attractive brochure has blue school logos and headings with black text on a white background. The graphic artist went through several iterations of format and text changes.

2.3 Formaldehyde Sampling and Analysis

2.3.1 Sampler Pre-Testing

ARB staff pre-tested the formaldehyde samplers in a new office building to evaluate method performance and potential shipping effects. Two sets of 5 samplers were opened and placed side by side in a new office building in downtown Sacramento, CA. The samplers were uncapped for 7 days and 14 days, respectively, in January 2001. The indoor location was an unoccupied cubicle in general office space. For field blanks and two field blanks, respectively, were placed along side the two sets of open samplers. All samplers and field blanks were from the same manufacturing batch.

The samplers and matching blanks were sent to the Air Quality Research (AQR) lab by express mail immediately after the exposure periods ended. The results of these tests, and of previous tests by the manufacturer, indicated that better precision was achieved for the longer sampling period (14 days). The results also showed that lab blanks varied among the batches, but that most of them were below 0.65 µg.

Based on these findings, ARB staff specified the following formaldehyde sampler protocols:

- Initial lab blank values for each batch must be no more than 0.75 µg.
- The number of batches was limited to one or two batches.
- The target sampling period was set at 10 days.
- Lab blank drift must be tested by AQR in 20 blanks per batch during each month of school sampling, and reported to ARB.

2.3.2 Sample Collection

Formaldehyde samples were collected over 7-to-10-day periods using the PF-1 passive sampling device developed by AQR. The device was suspended from the designated classroom ceilings according to specific instructions provided (see Appendix A). The tubes are shipped with a cap on each end. Once the tube is hung from the ceiling of the room, the cap is removed from one end. After the designated sampling period is completed, the cap is placed over the open end of the tube, and the sampling device is placed into the specially prepared package and shipped to the AQR laboratory for analysis. When exposure dates and/or times were missing callbacks were made to school study coordinators to acquire this information.

2.3.3 Sample Analysis

Analysis of the PF-1 tubes was performed by the AQR laboratory following NIOSH standard laboratory reference method 3500. The published minimum detection limit is " 10 ppb. The established shelf life of the PF-1 tubes prior to exposure is 6 months, with a shelf life after exposure of 1 month. Care was taken to be sure that all PF-1 tubes were deployed, returned, and analyzed within the 6 month shelf life. Also, a check was made to be sure that the sample after collection was analyzed within the 30 day shelf life.

2.4 Statistical Sampling Design

2.4.1 Selection of Sample Schools

The ARB and DHS decided that the Phase I PCS should be designed to provide approximately equal probabilities of selection for all public schools in CA using portable classrooms in Spring 2001, rather than approximately equal probabilities of selection for all *classrooms* in the public schools. One reason for this decision was concern that differences between portable and traditional classrooms might be primarily a function of differences between schools, rather than differences between individual classrooms. Hence, schools were selected with approximately equal probabilities, rather than with probabilities proportional to a measure of size correlated with the number of classrooms at each school. This sampling strategy produces an oversampling of classrooms in elementary schools because those schools usually have fewer rooms and students than middle schools and high schools.

The sampling frame for Phase I of the PCS was the California Public School Directory 2000 which was published by the California Department of Education Press. CA DHS staff sorted this frame by the county/district/school (CDS) code and selected a 1-in-7 systematic sample from the sorted frame, which resulted in an initial sample of 1,216 schools. Hence, the sample was implicitly stratified by county and district, ensuring representation of these geographic areas proportionate to the number of public schools in each area.

DHS then conducted a preliminary survey of the school districts with at least one school in this sample and identified 177 schools that did not have any portable classrooms. These schools were deleted from further consideration for the PCS, leaving 1,039 schools that were eligible for Phase I of the PCS. From these 1,039 eligible schools, 1,000 were randomly selected for Phase I of the PCS. Each school was sent a questionnaire for their facility manager and another for the primary teacher in each of three classrooms that were selected as described below.

The ARB and DHS wanted to conduct Phase I data collection during both cold and warm months because formaldehyde levels are known to depend on ambient temperatures. Hence, the sample was randomly assigned, by district, to two waves for mailout to the schools. The first (Wave 1) mailout went to a subsample of 600 randomly selected schools early in April 2001. The second (Wave 2) mailout went to the remaining 400 schools late in April 2001. Our initial plan was to send the first mailout earlier, but development of questionnaires and other survey materials forced the first mailing to be delayed until early April.

2.4.2 Selection of Schools to Receive Formaldehyde Monitors

For each wave of the Phase I sample, 80% of the sample schools were randomly selected to receive formaldehyde monitors (due to budget limitations affecting the number of formaldehyde samples). Hence, 480 of the 600 Wave 1 schools received formaldehyde monitors, and 320 of the 400 Wave 2 schools received formaldehyde monitors. Each school received passive formaldehyde monitors (and instructions for their use) to be deployed in three classrooms: two portable classrooms and one traditional classroom (unless the school had only one portable classroom or had no traditional classrooms).

2.4.3 Selection of Schools to Receive Quality Control (QC) Monitors

For each wave of the Phase I sample, 45% of the schools that had been selected to receive formaldehyde monitors were randomly selected to receive one additional formaldehyde monitor for QC sampling (blank and duplicate samples). Hence, 216 of the Wave 1 schools and 144 of the Wave 2 schools received an additional formaldehyde monitor for QC sampling. Within each wave, one-third of the schools in the QC sample (72 schools in Wave 1 and 48 schools in Wave 2) were randomly selected to receive one field blank formaldehyde monitor. The remaining two-thirds of the schools (144 in Wave 1 and 96 in Wave 2) were randomly selected to receive one duplicate monitor.[3] The sample classroom in which the duplicate monitor was to be placed was randomly assigned, subject to the restriction that the numbers of selections of Classrooms designated as A, B, and C by the sampling algorithm, were equal. Detailed instructions were provided regarding proper handling and deployment of the QC monitors (Appendix A).

2.4.4 Selection of Sample Classrooms

Both project time and budget limitations required that classroom samples be selected by school staff, rather than having the schools send classroom lists to RTI, having RTI select the samples, and communicating the sampling results back to the schools. Therefore, step-by-step instructions were developed for the schools to use to select sample classrooms, using stratified random sampling. Each school with two or more portable classrooms was led through the process of randomly selecting two portable classrooms (designated Classrooms A and B) and one traditional classroom (designated Classroom C). If the school had only one portable classroom, the allocations were reversed so that two traditional classrooms were selected in addition to the one portable classroom. If the school had no traditional classrooms, the school was led through random selection of three portable classrooms.

[3] Because each school had three sample classrooms, the classroom-level QC sampling rates were 5% for blanks and 10% for duplicates, or 15% overall.

2.5 Development of a Control System

A Microsoft Access survey control system was designed to monitor study progress. Before the control system was implemented, school IDs and other IDs were created. Every lead letter, postcard, questionnaire, and formaldehyde tube had an assigned ID. Every school had a four-digit numeric “school ID”. Each survey item was identified by the school ID followed by a three-character alpha suffix. School codes began with a leading 1 or 2, depending on whether the school was in Wave 1 or 2. The control system contained contact information from the district and schools obtained from the California Public School Directory 2000. Status codes were continuously updated for all schools that responded by postcard, phone call, or fax. Status codes included mailed, ineligible, returned postcard, refused, returned questionnaire (complete), returned questionnaire (blank), and referred to ARB.

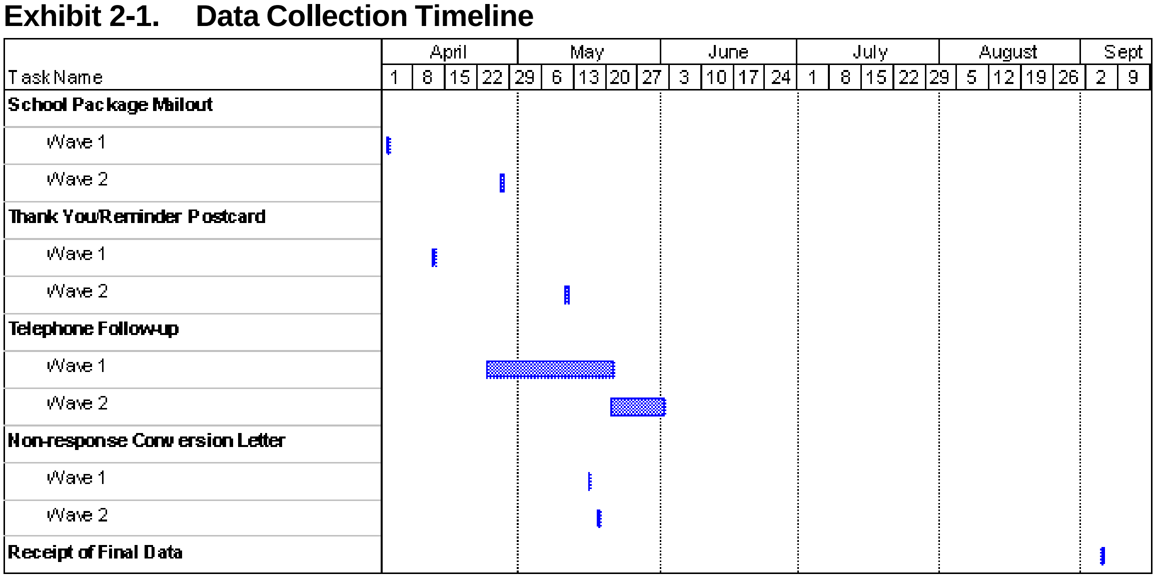
2.6 Data Collection

Once the survey materials were finalized, data collection activities (assembling the survey packages, mailing the materials, monitoring survey progress using the control system, and responding to telephone inquiries) began. The same data collection activities were carried out during both Waves 1 and 2. Exhibit 2-1 shows the overall timeline for data collection activities.

2.6.1 School Package Mailout

Preparation of the mailing packets took a great deal of organization and labor. For each wave, Federal Express boxes were obtained and labeled with the school name, ID, and whether or not the school received formaldehyde tubes. Survey materials such as the questionnaires, formaldehyde tube labels, analysis request forms, and principal postcards were organized and assembled by IDs. White envelopes were labeled with study coordinator; teachers A, B, and C; and facility manager to separate survey materials and ensure that the correct school staff person received each item. The instructions for preparing the survey packets are found in Appendix A.

Exhibit 2-1. Data Collection Timeline



2.6.2 Monitoring Progress with Control System

The control system was developed to manage the progress of the study. Each step in the mail survey process was associated with a status code. For example, Wave 1 sent out 600 principal lead letters on 3/23/2001, and subsequently the status codes were updated for those 600 IDs in the control system to “mailed”.

The control system also allowed record sub-setting to search for particular districts, schools, survey materials, and status codes. This feature was helpful in reviewing and/or updating responses of many large school districts. Refusals were passed along to ARB for an attempt at refusal conversion. Reports were ran with the control system to measure favorable responses, such as returned principal postcards, agreed to participate after telephone follow-up, or returned questionnaires. The control system proved to be a valuable tool for managing data collection activities.

2.6.3 Call Log

The project director and survey manager developed a “call log” to manage all incoming phone calls about the mail survey. Study participants called in by using the 1-800 number from the survey materials. The “call log” was a Microsoft Excel spreadsheet with fields for date, district and/or school, person who called, phone number, comments, and response. Study participants had a variety of questions and other concerns about the survey. Most of the calls were made regarding eligibility, questions about the instructions, refusals, and lost or discarded survey materials. Responses to phone calls were made as quickly as possible. Three hundred forty phone calls were entered and responded to as noted in the “call log.”

2.7 Efforts to Increase Participation

Participation rates are typically quite low for the initial round of mail surveys and there was a clear need to conduct follow-up with non-responding schools. To increase participation, five follow-up methods were used to prompt schools to participate in the survey. As a result, all non-respondents were contacted several times by postcards, letters, phone calls, emails, and/or faxes, as described below.

2.7.1 Thank You/Reminder Postcards

Postcards with the study letterhead were printed on plain white stock. The postcards were addressed to the principal with the intention of prompting the principal to begin work on the survey. Postcards were mailed ten to thirteen days after the school package was initially mailed.

2.7.2 Telephone Follow-up

RTI’s Telephone Survey Department conducted telephone follow-up with survey non-respondents. The purpose of this telephone call to the school principal was to prompt his/her school to participate.

A telephone interviewer's manual was developed and a training session was conducted with several telephone interviewers. Telephone interviewers were provided background information about the study and a copy of all the survey materials. Tracing control forms were utilized to track the calls and responses from each school. Interviewers were trained before beginning follow-up calls.

Telephone follow-up began about three weeks after the survey materials were mailed. During Wave 1 telephone follow-up, both non-responding schools and those that had returned postcards were called and prompted to return the survey materials. School principal names were not available, and this impeded our telephone follow-up efforts. Many school secretaries simply did not allow the telephone interviewers to speak with the principal. Multiple attempts were made for non-responding schools and this extended the time period in which follow-up was necessary. For Wave 2, non-respondents were given priority over those that had returned postcards and not all the Wave 2 schools that had returned postcards were prompted because of time limitations. At least three to four attempts were made to follow-up all non-responding schools that did not return the principal postcard from Waves 1 and 2.

Many schools responded that staff were simply too busy to complete the survey at the end of the school year. Some schools responded that they were currently undergoing aptitude testing and their teachers could not be involved. Often the superintendent would ask district facility managers or facilities staff to coordinate the survey activities of all the selected schools in their district. This became a difficult task for districts with four or more selected schools when the responsibility went to one person. Small schools had a difficult time completing the materials because the principal often wanted to assume all the responsibility of coordinating the survey activities at his/her school.

2.7.3 Non-response Conversion Letter

During telephone follow-up for Waves 1 and 2, a non-response conversion letter was sent to all non-respondents. This letter was addressed to the principal and copies were also sent to the facility manager. The letter reemphasized the importance of the study, encouraged participation, and established a deadline for the return of survey materials.

2.7.4 Replacement Mailings

Several schools responded that they had lost or thrown away the original survey materials but may be willing to participate if another package of the materials were mailed. The replacement mailing process involved reprinting questionnaires and other survey materials with the appropriate ID linkage and preparing the materials in the same manner as the original survey package. More than one hundred replacement mailings were made but only about thirty percent of those surveys were completed and returned.

2.7.5 District Level Follow-up

ARB and DHS wanted to monitor response rates in the large school districts like Los Angeles and San Diego. A list of the selected schools was supplied from those districts and the current response rate. ARB and DHS followed-up by contacting facility managers at these two districts and encouraging support.

Several large districts were contacted by phone or email to encourage support of the survey. This proved to be somewhat successful once the district facility manager was identified and contacted.

2.8 Data Processing

The data processing activities are described below for the formaldehyde data, the TQ data and the FQ data. An overview of the data processing steps is provided in Table 2-1. The result of these processing activities is the following set of data files that can be subjected to data analysis:

- Lab blank formaldehyde data—used for quality control (QC) data analyses and for background corrections for other formaldehyde data
- Field blank formaldehyde data—used for QC data analyses
- Duplicate sample formaldehyde data—used for QC data analyses
- School-level data from FQ (denoted as SCHOOL1 in Table 2-1)—used for school-level data analyses
- All classroom-level data (denoted as COMBIN4 in Table 2-1)—used for classroom-level data analyses.

Details on the processing steps are provided in the subsections below.

Table 2-1. Data Processing Overview

Task	Subtask*
A. Develop initial sampling weights (see Section 2.9)	A1. Develop file of school-level sampling weights, WTS A2. Develop file of classroom-level sampling weights, WTC
B. Process Formaldehyde data	B1. Extract QC data (field blanks, lab blanks, and field duplicates) from the overall file and save as 3 separate files B2. Take the balance of the file and confirm that it consists only of field data (call this file FD1) B3. Check FD1 to be sure that it includes only eligible schools/classrooms, modify if necessary to produce file FD2 B4. Review comments in FD2 data and examine concentrations for extreme values, flag suspect data and non-detects to produce FD3 file
C. Process Teacher Questionnaire data	C1. Check schools/classrooms for eligibility, include eligibles in file TC1, one record per classroom
D. Process Facility Manager Questionnaire data	D1. Extract variables associated with schools and create Facility Manager School data file FMS1, one record per school D2. Check schools in FMS1 for eligibility, merge with WTS, create adjusted school-level sampling weights and add them to create file SCHOOL1 D3. Extract variables associated with classrooms and create Facility Manager Classroom file FMC1, one record per classroom D4. Check schools/classrooms in FMC1 for eligibility, modify if necessary to form file FMC2
E. Create combined classroom-level analysis file	E1. Merge data from FD3 and FMC2 onto TC1 file to form file COMBIN1 E2. Merge COMBIN1 with WTC, create adjusted classroom-level sampling weights and add them to COMBIN1 file to form file COMBIN2 E3. Add other data (e.g., geographic identifiers) and recode variables where necessary (e.g., to handle multiple responses) to form file COMBIN3 E4. Recode data in COMBIN3 to properly handle skip patterns and to create analysis variables to form file COMBIN4

* File name abbreviations, other than SCHOOL1, COMBIN3, and COMBIN4, do not correspond to actual files, but are used to indicate the process.

2.8.1 Process Formaldehyde Data

The formaldehyde data were provided by AQR in Excel spreadsheets. The data included the instrument response, denoted as y, along with the pertinent identifying information, the pertinent calibration data, and the start and stop dates and times of the exposure period. Comments were provided by AQR whenever unusual circumstances occurred. The calibration model was estimated by AQR by regressing Y on X, where Y is the instrument response that corresponds to known levels of formaldehyde mass, X (in μg). If the calibration model is denoted as $Y = a + bX$, where a and b are the intercept and slope estimates, respectively, then the formaldehyde mass for a sample yielding response y was determined by AQR as

$$\hat{X} = 2\frac{y-a}{b},$$

where the constant "2" appearing in the above is a dilution factor.

Formaldehyde concentrations were then computed by AQR as

$$Z^* = \frac{\hat{X} - \overline{X}_b}{0.31T}$$

where Z is the concentration in ppm, $\hat{X}$ is the mass (µg)obtained from the above equation, $\overline{X}_b$ is the average mass (µg) of laboratory blank samples associated with the measurement, and T is the duration in hours that the vial was exposed. The time T was determined from the start and stop dates and times. The constant 0.31 is a diffusion rate (g air/hr) associated with the tubes.[4] The percentage distribution of sampling durations is given below:

No. sampling days*	Percent
4-8	11
9-10	71
11-14	14
15-18	3
>18	1

* Days were determined as the difference in sampling stop date and start date.

Data from the spreadsheets were originally partitioned into two SAS files: one containing the lab blank data and one containing all of the other data. For the latter file, the comments provided by the laboratory were reviewed and each analysis result was assigned a data quality flag (DQFLAG) of 0, 1, or 2. Values of 2 were assigned when a severe problem with the analysis occurred or when the integrity of the sample could not be assured. Less severe problems (e.g., exact start and stop times not available) were flagged with a value of 1. All other cases were assigned a value of 0. The distribution of the data quality flags across the observations (including field blanks and duplicate samples) was as follows:

DQFLAG Value	Meaning	Frequency Counts				Freq. (%)
		Field Obs.	Dup Samples	Blank Samples	Total	
0	Data considered okay	796	60	34	890	77.3
1	Data considered suspect	115	7	7	129	11.2
0 or 1	Data considered usable	911	67	41	1019	88.5
2	Data considered invalid	97	23	12	132	11.5

Three different versions of concentration variates were constructed:

1. $Z = 1000\ Z^*$ (the factor 1000 was used to convert the results from ppm to ppb)
2. $Z_0 = \max(Z,0)$ (convert negative values to 0)
3. $Z_1 = \max(Z,0.1)$ (convert negative, zero, and small positives to 0.1)

[4] Note that this approach for computing Z* can yield negative concentration values.

In general, Z_1 was used in all data analyses, except for those dealing with field blanks, for which only Z was used. A non-detect indicator was set equal to 0 if Z exceeded 6 ppb, and equal to 1, otherwise.

The file containing the field data was then partitioned into three separate files; each file contained only those records having DQFLAG=0 or 1. These files were:

- File of field observations (911 records). This file includes 6 observations originally designated as a field duplicate but for which the original sample was not obtained or was deemed invalid. After augmentation of some school-specific data (e.g., school location, school type), some classroom-specific data (portable versus traditional indicator), and adjusted sampling weights (see Section 2.9), this file was used for all formaldehyde-related data analyses.
- File of duplicate field observations (67 x 2 = 134 records)
- File of field blank observations (41 observations).

The last two of these files were used for QC purposes.

2.8.2 Process Teacher Questionnaire (TQ) Data

The teacher questionnaires were scanned and compiled in a Microsoft Excel Comma Separated Values (CSV) file. Data were compiled on three separate dates: June 28, July 17, and August 28, 2001. This file contained a total of 1208 records. Three records were deleted because they contained no data (1219TQC, 1402TQA, and 2184TQC) and 24 records were deleted because the original questionnaire was scanned twice. The final TQ file therefore contained 1181 records.

These data were cleaned to correct for the following:

- Invalid or missing date information in the DATE field,
- Deletion of duplicate or empty records (as indicated above),
- Input of missing TQ_ID information per LINK field or hard copy of questionnaire, and
- Miscellaneous corrections made to data per hard copy.

Fields with invalid multiple responses were originally given a missing value. These records were later reviewed and the following adjustments were made:

- A value of ‘8’ was given to records with multiple responses in the following fields: TQ2 and TQ11
- A value of ‘12’ was given to records with multiple responses to TQ5
- A special missing value of ‘.M’ was given to records with multiple response in the following fields: TQ3A, TQ7, TQ15, TQ16A, TQ16B, TQ28, TQ30A, TQ30B, TQ30F, TQ33, TQ36, TQ37, TQ41, and TQ43
- New variables were created due to multiple responses in TQ18B. These variables are TQ18B_1, TQ18B_2, and TQ18B_3. Values of ‘Yes’ = 1 and values of ‘No’ = 2

- New variables were created due to multiple responses in TQ38B. These variables are TQ38B_1 to TQ38B_5. Values of ‘Yes’ = 1 and values of ‘No’ = 2.

2.8.3 Process Facility Questionnaire (FQ) Data

The facility questionnaires were scanned and compiled in a Microsoft Excel CSV file. Data were compiled on three separate dates: June 28, July 17, and August 28, 2001. There were a total of 386 records. Two records were deleted because the original questionnaire was scanned twice (1051FMQ and 1520FMQ). The final FQ file therefore contained 384 records.

The data were cleaned to correct the following issues like those indicated above for the TQ. In addition, fields with invalid multiple responses that were originally given a missing value were later reviewed and the following adjustments were made:

- A value of ‘8’ was given to records with multiple response in the following fields: FQ1 and FQ14
- A special missing value of ‘.M’ was given to records with multiple response in the following fields: FQ2, FQ3, FQ8, FQ15AA, FQ15AB, FQ15AD, FQ15AE, FQ16B, FQ16C, FQ18, FQ19B, FQ24, FQ25, FQ25AD, FQ25BA, FQ25BC, FQ25BE, FQ27AC, FQ31B, FQ32A, FQ32B, FQ32C, FQ33A, FQ33C, FQ34AA, FQ34AC, FQ34BA, FQ34CA, FQ35B, FQ36A, FQ36B, FQ36C, FQ37A, FQ37B, FQ37C, FQ38A, FQ38B, FQ41A, FQ42A, FQ42B, FQ42C, FQ43A, FQ45A, FQ46A, FQ46B, FQ46C, FQ47A, FQ58CA, FQ59A, and FQ61A
- New variables were created due to multiple responses in FQ44A. These variables are FQ44A1 to FQ44A6. Values of ‘Yes’ = 1 and values of ‘No’ = 2
- New variables were created due to multiple responses in FQ44B. These variables are FQ44B1 to FQ44B6. Values of ‘Yes’ = 1 and values of ‘No’ = 2
- New variables were created due to multiple responses in FQ44C. These variables are FQ44C1 to FQ44C6. Values of ‘Yes’ = 1 and values of ‘No’ = 2
- New variables were created due to multiple responses in FQ52A. These variables are FQ52A1 to FQ52A6. Values of ‘Yes’ = 1 and values of ‘No’ = 2
- New variables were created due to multiple responses in FQ52B. These variables are FQ52B1 to FQ52B6. Values of ‘Yes’ = 1 and values of ‘No’ = 2
- New variables were created due to multiple responses in FQ52C. These variables are FQ52C1 to FQ52C6. Values of ‘Yes’ = 1 and values of ‘No’ = 2

After making the above changes, the FQ was partitioned into two files—one at the school level and one at the classroom level. The former retained data on items 1 through 26. The latter involved transposing questions 27 to 64 so each classroom was associated with a record (i.e., usually three records per school) in the FQ classroom file. These records were matched with the teacher classroom records by ROOM name/number (see Section 2.8.4). The records were linked by a variable named FQ_RMKEY. This file was used to create the classroom level file.

The final <u>school-level file</u> contains a separate record for each school. This file contains:

- the pertinent identifiers (e.g., school ID)
- school-specific data from the FQ

- sampling weights associated with schools (see Section 2.9)
- other classification variables based on information from CA ARB and DHS:
  - School level: elementary, middle, high schools (based on highest grade)
  - School location: urban (cities with 250,000+ population)
rural (including towns under 25,000 population
suburban (all other)
  - Region: the southern boundaries of Monterey, Fresno, and Mono Counties were used to partition Northern and Southern California (see Figure 2-1)
  - Percent of children receiving Aid to Families with Dependent Children (AFDC)
  - Percent of children receiving Federal meals assistance
  - Expenditure per student.

2.8.4 Creation of Combined Classroom-Level Analysis File

As with the school file, pertinent transformations and combinations of the classroom-level response variables that were needed for data analysis were developed as a part of the file construction processes. These analysis variables are described in Section 2.10. As a part of the file creation process, preliminary data summaries and analyses (e.g., scatter plots, tabulations, and basic summary statistics) were performed on the primary variables to identify anomalies and to determine if additional data transformations and recoding (e.g., collapsing of response categories) were necessary for subsequent analyses.

The final <u>classroom-level file</u> contains a separate data record for each classroom. This file contains

- the pertinent identifiers and classification variables (e.g., area [north or south], school ID, classroom type and ID)
- questionnaire data from the TQ
- classroom-specific questionnaire data from the FQ
- formaldehyde concentration data and associated lab results, including data quality status and measurability status indicators
- sampling weights associated with schools and classrooms (see Section 2.9).

One of the major efforts in the data processing related to properly identifying classrooms so that the various types of data (formaldehyde, TQ , and FQ) could be linked at the classroom level. The initial intent of the classroom selection process was that there would be three rooms per school: two portable classrooms, designated as A and B, and one traditional classroom, designated as C. These procedures were not always followed by both the teachers and the facility managers, which resulted in some inconsistencies between the two. The following rules were developed in order to match the FQ and TQ data at the classroom level as accurately as possible and to construct a consistent room type variable (called ROOMTYPE) from the room numbers appearing in the TQ and in the FQ:

- If two of the three room numbers at a school are matches or near matches (like B-4 and 4), then consider the third room to be matched also, even if the room numbers reported are different (like 205 and 12).

Figure 2-1. Definition of Northern and Southern California for the Portable Classrooms Study

- If only one or none of the three room numbers are matches, keep the FQ data only for the matching room (if any) and disregard the remainder of the FQ data (This assumes that the FQ data have not been provided for the same rooms as the TQ and the formaldehyde tubes. Such FQ data are retained in the data files with room designations of D, E, or F, which will not match the TQ or formaldehyde data records.).
- If the Room ID for the TQ ends in A or B:
  - If either the TQ or the FQ classifies the room as portable, then classify the room as portable.
  - Otherwise, if either classifies the room as permanent, classify the room as permanent.
  - Otherwise, classify the room as portable.
- If the Room ID for the TQ ends in C:
  - If either the TQ or the FQ classifies the room as permanent, then classify the room as permanent.
  - Otherwise, if either classifies the room as portable, classify the room as portable.
  - Otherwise, classify the room as permanent.
- If no TQ is available, but a FQ is available:
  - Use the FQ, if provided, to classify Rooms A, B, and C as portable or permanent.
  - Otherwise, assume that Rooms A and B are portable and C is permanent.
- If neither a TQ or FQ is available, but formaldehyde monitor results are available, assume that Rooms A and B are portable and that room C is permanent.

2.8.5 Preparation of Data for Analysis

School-Level File. Additional processing of the school level file (called SCHOOL) was needed prior to conducting statistical analyses. This included the following two main types of activities: recoding of selected variables, and creation of analysis variables, as indicated in Tables 2-2 and 2-3, respectively.

The final file, called SHCOOL1, included all of the original variables on the SCHOOL file plus the newly created variables; the SCHOOL1 file serves as the basis for all school-level analyses.

Table 2-2. Final Processing Activities for SCHOOL File

Item	Activity	New Item
FQ15A	Item was inadvertently not scanned; value inferred from subsequent parts of item (1=yes, 2=no or NA)	RFQ15
FQ12A FQ12B	Temperatures below 60 or above 85 degrees recoded as bad data	RFQ12A RFQ12B
P_CALWORKS	Create categorical variable to indicate if value is <=25% (1=yes, 2=no)	P_CALWOR
P_MEALS	Create categorical variable to indicate if value is <=55% (1=yes, 2=no)	P_MEAL
AVGCOSTA	Create categorical variable to indicate if value is <=$5500 (1=yes, 2=no)	PAVGCOST
POPSTATUS	Character values converted to numeric	POPSTAT
SCH_TYPE	Character values converted to numeric	SCHTYPE
NORTHSOUTH	Character values converted to numeric (1=N,2=S)	REGION

Table 2-3. School-Level Analysis Variables

Variable	Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Source
POPSTAT	School location	Urban	Suburb	Rural					O
REGION	Geographic region	North	South						O
SCHTYPE	School type	Elem	Middle	High					O
P_CALWOR	Percent students on AFDC	<=25%	>25%						O
P_MEAL	Percent students on Meal Assistance	<=55%	>55%						O
PAVGCOST	Avg Student Expenditure	<=$5500	>$5500						O
SCHAGE	School age (yrs)	<=10yr	11-20yr	21-30yr	31-40yr	41-50yr	50+yr	Unspec	FQ6
NUMPORT	Number of portable classrooms	1-10	11-20	21-30	>30				FQ7a
NUMTRAD	Number of traditional classrooms	1-20	21-40	41-60	>60				FQ7b
NUMTOT	Total number classrooms	1-30	31-60	61-100	>100				FQ7a,b
HVACLOG	HVAC maintenance logs kept	Yes	No	DK					FQ11a-g
RFQ15	Regular HVAC inspection/maintenance	Yes	No/NA						FQ15*
FQ15AA	HVAC I&M: outdr damper setting	Monthly	Quarterly	Yearly	>Year	Never	DK	NA	FQ15aa
FQ15AB	HVAC I&M: coils cleaned	Monthly	Quarterly	Yearly	>Year	Never	DK	NA	FQ15ab
FQ15AC	HVAC I&M: condensate pan/drain	Monthly	Quarterly	Yearly	>Year	Never	DK	NA	FQ15ac
FQ15AD	HVAC I&M: filter replaced	Monthly	Quarterly	Yearly	>Year	Never	DK	NA	FQ15ad
FQ15AE	HVAC I&M: exchanger checked	Monthly	Quarterly	Yearly	>Year	Never	DK	NA	FQ15ae
FQ16A	Freq of trash removal	5/wk	3-4/wk	1-2/wk	1-2/mo	<1/mo			FQ16a
FQ16B	Freq of vacuuming/sweeping/dusting	5/wk	3-4/wk	1-2/wk	1-2/mo	<1/mo			FQ16b
FQ16C	Freq of carpet steam/dry cleaning	5/wk	3-4/wk	1-2/wk	1-2/mo	<1/mo			FQ16c
FQ19A	Aware of EPA IAQ Tools for Schools Pgm	Yes	No						FQ19a
USETOL	Awareness/use of EPA IAQ Tools	Aware/yes	Aware/no	Aware/DK	Unaware				FQ19a,b
FQ25	Any major complaints of envir cond	Yes	No	DK					FQ25
RFQ25AA	Roof leak complaint last yr: Port	None	1	2-4	5-9	10+			FQ25,FQ25aa
RFQ25AB	Plumbing leak complaint last yr: Port	None	1	2-4	5-9	10+			FQ25,FQ25ab
RFQ25AC	Air/odor complaint last yr: Port	None	1	2-4	5-9	10+			FQ25,FQ25ac

Variable	Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Source
RFQ25AD	Mold complaint last yr: Port	None	1	2-4	5-9	10+			FQ25,FQ25ad
RFQ25AE	Temperature complaint last yr: Port	None	1	2-4	5-9	10+			FQ25,FQ25ae
RFQ25AF	Noise complaint last yr: Port	None	1	2-4	5-9	10+			FQ25,FQ25af
RFQ25BA	Roof leak complaint last yr: Trad	None	1	2-4	5-9	10+			FQ25,FQ25ba
RFQ25BB	Plumbing leak complaint last yr: Trad	None	1	2-4	5-9	10+			FQ25,FQ25bb
RFQ25BC	Air/odor complaint last yr: Trad	None	1	2-4	5-9	10+			FQ25,FQ25bc
RFQ25BD	Mold complaint last yr: Trad	None	1	2-4	5-9	10+			FQ25,FQ25bd
RFQ25BE	Temperature complaint last yr: Trad	None	1	2-4	5-9	10+			FQ25,FQ25be
RFQ25BF	Noise complaint last yr: Trad	None	1	2-4	5-9	10+			FQ25,FQ25bf
PORTCP	Port classroom envir complaints	Yes	No	DK					FQ25,aa-af
TRADCP	Trad classroom envir complaints	Yes	No	DK					FQ25,ba-bf

“Source” identifies the questionnaire item(s) from which the variable was derived. The “0” cases were from sources other than a questionnaire.

The percent of children in the school who receive AFDC assistance, P_CALWORKS, was recoded into P_CALWOR as shown in Table 2-2 by defining the first category to be the schools with either zero or very low AFDC assistance. The percent of children receiving Federal meals assistance, P_MEALS, and the average expenditure per student, AVGCOST, were recoded as shown by reviewing the distributions of these variables and choosing natural breakpoints near the middle of the distributions.

Classroom-Level File. Additional processing of the combined classroom level file (called COMBIN3) was needed prior to conducting statistical analyses. This included the following two main types of activities: recoding of selected variables, and creation of analysis variables. Table 2-4 summarizes the recoding activities, and Table 2-5, the creation of analysis variables. The final file, called COMBIN4, included all of the original variables on the COMBIN3 file plus the newly created variables; the COMBIN4 file serves as the basis for all classroom-level analyses. The next to last column indicates the source of the analysis variable (0=other). The last column of Table 2-5 indicates how the particular analysis variables are used:

M = multiple use
F = formaldehyde analyses
P = population-characterization analyses
B = both F and P.

Table 2-4. Final Recoding Activities for COMBIN3 File

Item	Activity	New Item
TQ15	Reorder levels into logical sequence	RTQ15
TQ16A TQ16B	Force skip-pattern consistency between items; reorder levels of TQ16B into logical sequence	RTQ16A RTQ16B
TQ18A TQ18B	Force skip-pattern consistency between items	TQ18A TQ18B
TQ31 (all parts)	Force skip-pattern consistency between items	RQ31 (all parts)
TQ32 (all parts)	Force skip-pattern consistency between items	RQ32 (all parts)
TQ33	Reorder levels into logical sequence	RTQ33
TQ34A TQ34B	Force skip-pattern consistency between items	RT34A RTQ34B
TQ38A TQ38B_1,2,3,4,5	Force skip-pattern consistency between items; convert levels for RTQ38_x items (1=yes, 2=no, 3=NA)	RTQ38A RTQ38B_1,2,3,4,5
TQ40B_A,B,C,D	Force skip-pattern consistency with TQ40A_B; recode for multiple responses and combine into one variable	RTQ40B

Table 2-5. Classroom-Level Analysis Variables

Variable	Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Source	Analysis Type
ROOMTYPE	Classroom type	Portable	Traditional					O	M
OVERALL	All classrooms	All						O	B
POPSTAT	School location	Urban	Suburb	Rural				O	B
REGION	Geographic region	North	South					O	B
SCHTYPE	School type	Elem	Middle	High				O	B
SAMPMO	Month of formaldehyde sample	April	May	June/July*				H2CO data	F
SAMPTIME	Time of formaldehyde sample	Early_April	Late_April	Early_May	Late_May	June/July		H2CO data	F
PWDXPOSC	<25% non-weekday in samp period	Yes	No					H2CO data	F
GENINST	General instruction classroom	Yes	No					TQ5	B
NUMSTUD	Typical number students in class	0-9	10-19	20-29	30-39	>40		TQ8	P
FLRTYP	Type of flooring	Carpet_only	Vinyl/linol	Both	Carpet_comb	Other		TQ10a-i	P
CARPET	Carpeted classroom	Full	Partial	None				TQ10a/b	B
VINYLFL	Vinyl/linoleum floor	Yes	No					TQ10e	B
VINYLWL	Vinyl tackable wallboard	Yes	No					TQ11	B
TQ11	Primary wall material	Sh_rock/pls	vinyl_tack	cinderblk	other/DK			TQ11	P
WINDOPEN	Open windows	Never	Infrequent	Frequent				TQ15	B
RTQ15	Freq of open windows	Unopenable	Rarely	Occasional	Frequently	Most_time	Always	TQ15	P
DOOROPEN	Open door to outside	Infreq	Freq	NA				TQ16b	B
RTQ16B	Freq of open exterior door	NA	Rarely	Occasional	Frequently	Most_time	Always	TQ16b	P
TQ17	Air conditioning in room	Yes	No					TQ17	P
TQ18A	Thermostat in room	Yes	No	DK				TQ18A	P
RTQ18B	Thermostat adjustment	Adjustable	Locked_up	Not_working	Unspecified	NA/DK		TQ18b	P
PRESWOOD	Pressed wood furniture	Yes	No					TQ19	B
PRESWOD1	Pressed wood table/desks	Yes	No					TQ19a	B
PRESWOD2	Pressed wood bookcases	Yes	No					TQ19b	B
PRESWOD3	Pressed wood cabinets	Yes	No					TQ19c	B
PLASTIC	Plastic furniture	Yes	No					TQ19	P

Variable	Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Source	Analysis Type
NEWFURN	New furnishings this school yr	Yes	No	DK				TQ20	B
COPIERS	Copiers present in room	Yes	No					TQ22a	P
APPLIAN	Type appliances in room	Stove/burnr	Other	None				TQ22b	B
CHEMPRES	Chemical present in room	Yes	No					TQ22c	B
PAINTPEN	Paints/pens used	Yes	No					TQ23a	P
PAINTS	Oil/acrylic paints used	Yes	No					TQ23a_b	F
PMARKER	Permanent marker/pen used	Yes	No					TQ23a_c	F
WBMARKER	Whiteboard marker used	Yes	No					TQ23a_d	F
GLUFLU	Glues/fluids used	Yes	No					TQ23b	B
CORFLU	Correction fluid used	Yes	No					TQ23b_c	F
GLUES	Epoxy/rubber cement used	Yes	No					TQ23b_b/d	F
AFRESH	Air freshener used	Yes	No					TQ23c	B
AFRESHP	Air freshener used - plug-in	Yes	No					TQ23c_c	F
AFRESHS	Air freshener used - spray	Yes	No					TQ23c_d	F
CANDLES	Candles used	Yes	No					TQ23d	P
AIRCLEAN	Air cleaners used	Yes	No					TQ23e	P
AIRPURF	Portable air purifier used	Yes	No					TQ23e_b	P
PESTUSE	Pesticide use past yr (teacher)	Current	Previous	Never				TQ24	P
PESTSPR	Pesticide spray use past yr	Yes	No					TQ24a	P
PESTPOW	Pesticide powder use past yr	Yes	No					TQ24b	P
PESTTRP	Pesticide trap use past yr	Yes	No					TQ24c	P
CLASPREF	Teacher classroom preference	Permanent	Portable	No_Opinion				TQ25	P
TEMP	Classroom temperature	Okay	Cold	Hot				TQ26a	P
HUMID	Classroom humidity	Okay	Humid	Dry				TQ26b	P
CAIR	Classroom air	Okay	Drafty	Stuffy				TQ26c	P
LIGHT	Classroom light	Okay	Dim	Bright				TQ26d	P
INNOISE	Disruptive inside noise	Yes	No					TQ27a	P

Variable	Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Source	Analysis Type
OUTNOISE	Disruptive outside noise	Yes	No					TQ27b	P
TURNOFF	Turn off heat/AC due to noise	Yes	No					TQ28	P
BUGPROB	Bug problems in room	Current	Previous	Never				TQ29a	P
RODPROB	Rodent problems in room	Current	Previous	Never				TQ29b	P
MUSTODOR	Musty odor	Never	Sometimes	Often				TQ30a	P
NEWODOR	New furnishings odor	Never	Sometimes	Often				TQ30d	B
RTQ30A	Musty odor at times	Yes	No					TQ30a	P
RTQ30B	Cleaning products odor at times	Yes	No					TQ30b	P
RTQ30C	Vehicle exhaust odor at times	Yes	No					TQ30c	P
RTQ30D	New carpet/furniture odor at times	Yes	No					TQ30d	P
RTQ30E	Fresh paint odor at times	Yes	No					TQ30e	P
RTQ30F	Cooking odor at times	Yes	No					TQ30f	P
RTQ30G	Pesticide odor at times	Yes	No					TQ30g	P
RTQ30H	Asphalt/tar odor at times	Yes	No					TQ30h	P
RTQ30I	Tobacco smoke odor at times	Yes	No					TQ30i	P
RTQ30J	Trash/dumpster odor at times	Yes	No					TQ30j	P
RTQ30K	Sewer/compost odor at times	Yes	No					TQ30k	P
RTQ30L	Fire/smoke odor at times	Yes	No					TQ30l	P
CONST	Construction activity this yr	Current	Previous	Never	Unknown			TQ31a	B
RTQ31C_B	Carpentry activity this yr	Yes	No					TQ31c_b	B
RTQ31B_A	In-room construction this yr	Yes	No					TQ31b_a	B
OTHCONST	Other school construction this yr	Yes	No					TQ31b_b-e	B
RTQ31B_B	Same building construction this yr	Yes	No					TQ31b_b	P
WATRPRB	Evidence of water problems (teacher)	Current	Previous	Never	Unknown			TQ32	P
WATRLEK	Leak or flood in room	Current	Previous	Never	Unknown			TQ32a	P
TYPLEK	Type leak or flood	Roof	Other	Both	No_Leaks			TQ32b	P
WATRSTN	Water stains in room	Current	Previous	Never	Unknown			TQ32c	P

Variable	Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Source	Analysis Type
TYPSTN	Type water stains	Ceiling	Floor	Both	Other	No_Stains		TQ32d	P
VISMOLT	Visible mold in room (teacher)	Current	Previous	Never	Unknown			TQ32e	P
MOLDLOC	No. locations with mold	No mold	1-2_loc	3+loc				TQ32f	P
FLSWEP	Freq of floor cleaning	Daily	2-3/wk	1/wk	Other	DK		TQ33	P
RTQ34B	Custodial services needed	More_freq	More_effctv	Both	Unspecified	NA		TQ34a/b	P
COMPLAN	# teacher complaints in school yr	0	1-5	>5				TQ36	B
TQ37	Overall air quality (teacher)	Excellent	Good	Adequate	Poor	Very_poor		TQ37	B
AIRQUAL	Overall air quality (teacher)	Excel/Good	Adequate	Poor				TQ37	P
ABSENT	Days absent last 2 weeks	None	1-2_days	>2_days				TQ38a	P
CAUSE	Reason for absence	Cold/flu	Allerg/resp	NA				TQ38b	P
NOSESYM	Nose symptoms past 2 weeks	None	Occasional	Frequent				TQ39a_n/o/f	B
THRTSYM	Throat symptoms past 2 weeks	None	Occasional	Frequent				TQ39b_n/o/f	B
EYESSYM	Eyes symptoms past 2 weeks	None	Occasional	Frequent				TQ39c_n/o/f	B
SKINSYM	Skin symptoms past 2 weeks	None	Occasional	Frequent				TQ39d_n/o/f	P
HEADSYM	Headache/sinus pain past 2 weeks	None	Occasional	Frequent				TQ39e_n/o/f	P
DROWSYM	Drowsiness past 2 weeks	None	Occasional	Frequent				TQ39f_n/o/f	P
DIZZSYM	Dizziness/faintness past 2 weeks	None	Occasional	Frequent				TQ39g_n/o/f	P
LUNGSYM	Lung symptoms past 2 weeks	None	Occasional	Frequent				TQ39h_n/o/f	P
STOMSYM	Upset stomach past 2 weeks	None	Occasional	Frequent				TQ39i_n/o/f	P
NOSESYMI	Nose symptoms at home	Same/worse	Improves	NA				TQ39a_s/i	B
THRTSYMI	Throat symptoms at home	Same/worse	Improves	NA				TQ39b_s/i	B
EYESSYMI	Eyes symptoms at home	Same/worse	Improves	NA				TQ39c_s/i	B
SKINSYMI	Skin symptoms at home	Same/worse	Improves	NA				TQ39d_s/i	P
HEADSYMI	Headache/sinus pain at home	Same/worse	Improves	NA				TQ39e_s/i	P
DROWSYMI	Drowsiness at home	Same/worse	Improves	NA				TQ39f_s/i	P
DIZZSYMI	Dizziness/faintness at home	Same/worse	Improves	NA				TQ39g_s/i	P
LUNGSYMI	Lung symptoms at home	Same/worse	Improves	NA				TQ39h_s/i	P

Variable	Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Source	Analysis Type
STOMSYMI	Upset stomach at home	Same/worse	Improves	NA				TQ39i_s/i	P
NUMSYM	No. health symptoms past 2 weeks	None	1-2	3+				TQ39	P
ALLERG	Chronic hay fever/allergies	Yes	No					TQ40a_a	P
LUNGPRB	Chronic asthma/bronchitis	Yes	No					TQ40a_b/c	P
CIRCPRB	Chronic hypertension/heart disease	Yes	No					TQ40a_d/e	P
ASMED	Inhaled asthma med past 2 weeks	Never	Some	NA				TQ40a/b	P
STUASMA	No. students taking asthma med	DK	None	1-2	3-5	6+		TQ41	P
PORTTYP	Type of Classroom	Port-DSA	Port-DOH	Port-Unk	Trad	Trad?		FtypePort	P
CLRAGE	Classroom age (yrs)	<=10yr	11-20yr	21-30yr	31-40yr	41+yr		Fyrconst	B
CLRAGEX	Classroom age (yrs)	0-3yr	4-5yr	6-10yr	11-15yr	16+yr		Fyrconst	B
CLRAGEU	Classroom age (known/unknown)	Known	Unknown					Fyrconst	B
RENOVAT	Major renovations/additions	Yes	No					FQ29	B
RENOVMAJ	Addition/wall/floor renovations	Yes	No					FQ29_a/e/f	B
RENOVELE	HVAC or lighting renovations	Yes	No					FQ29_b/c	B
RENOVRUF	Roof renovations	Yes	No					FQ29_d	B
CLRSIZ	Classroom size (sq. ft.)	<600	600-1100	>1100				FQ31	B
BLDGFON	Building foundation type	<Grade	Slab	Raised_Flr				FQ34_a	P
RFQ34C	Floor Height (in)	<6	6-11	12-17	18+	NA/Unk		FQ34c	P
RUFTYP	Roof type	Membrane	Composite	Tar/gravel	Metal	Other		FQ36	P
FQ37	Roof pitch	Flat	Sloped	Both				FQ37	P
FQ38	Suspended ceilings	Yes	No					FQ38	P
LDDOCK	Load dock/parking/road in 50ft	Yes	No					FQ39_a/b	P
DUMPSTR	Dumpster within 50ft	Yes	No					FQ39_d	P
SPROOMS	Spec purpose rooms within 50ft	Yes	No					FQ39	P
PELPANI	Peeling paint inside	Yes	No					FQ40_a	P
PELPANO	Peeling paint outside	Yes	No					FQ40_b	P
PELPANT	Peeling paint in or out	Yes	No					FQ40_a/b	P

Variable	Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Source	Analysis Type
PACHVAC	Packaged HVAC	Yes	No	DK	NA			FQ41	P
AHULOC	Main AHU Location	Wall	Roof	Floor/Othr	DK	NA		FQ42	P
CENTAC	Central cooling system	Yes	No	DK	NA			FQ45	P
FANOP	HVAC supply fan operation	Auto	Always_on	Other/unspe				FQ46	P
DAMPSET	Outdoor damper min setting	<=10%	11-20%	21-40%	>40%	Unknown		FQ48	B
PLENOPEN	Plenum open	Yes	No					FQ49_a	P
FGLFILT	HVAC fiberglass mesh filter	Yes	No					FQ50_a	P
PLEFILT	HVAC pleated filter	Yes	No					FQ50_b	P
HIEFILT	HVAC high efficiency filter	Yes	No					FQ50_c	P
TCNTL	Thermostat control	Teacher	Others	Both	DK	NA		FQ52	P
SPHEAT	Space heaters used	Yes	No					FQ53_a-f	P
WATRDAM	Water damage past 3 yrs (FM)	Yes	No	DK				FQ56	P
RUFLEAK	Roof leaks last 3 yrs (FM)	Yes	No					FQ56_a	P
VISMOLD	Visible mold past 3 yrs (FM)	Yes	No	DK				FQ57	P
STDWATR	Standing water within 50ft	Yes	No	DK				FQ59	P
NEWWOOD	New pressed wood last yr	Yes	No	DK				FQ60	B
FQ61	Paint/caulk/seal last yr	Yes	No	DK				FQ61	P
NEWCARP	New carpet past yr	Yes	No					FQ62_a	B
NEWFLOOR	New flooring past yr	Yes	No	DK				FQ62	B
PESTUSEF	Pesticide use past yr (FM)	Yes	No	DK				FQ63	P
CCPEST	Crack/crevice pesticides last yr	Yes	No					FQ63_a	P
SPPEST	Spray can pesticides last yr	Yes	No					FQ63_d	P
FLUBULB	Fluorescent bulbs	T8	T12	Both	No/DK			FQ64_a/b	P

* Includes classrooms (4 cases) where the sample time was unknown.
"Source" identifies the questionnaire item(s) from which the variable was derived. The "0" cases were from sources other than a questionnaire.
Analysis type codes:
P = population characterization analyses
F = formaldehyde concentration analyses
B = both
M = multiple.

2.9 Statistical Analysis Weights

2.9.1 Initial School-level Weights

Whenever units are selected from a population with known probabilities, unbiased estimates of population totals (e.g., total number of CA public schools with portable classrooms in Spring 2001) are achieved by weighting the survey responses by the reciprocals of their probabilities of selection, including appropriate adjustments for survey nonresponse. Hence, the initial sampling weight for each of the 1,000 CA public schools randomly selected for Phase I is the product of 7 and 1.039 (i.e., initial weight = 7.273) to account for selection of a 1-in-7 systematic sample and a random subsample of 1,000 schools of the 1,039 eligible schools initially selected. Likewise, the initial sampling weight for the 800 schools randomly selected to receive formaldehyde monitors is the product of this weight and 1000/800 (i.e., initial weight = 9.09125) to account for randomly selecting a subsample of 800 schools from the 1,000 selected to receive questionnaires.

All of the ineligible schools in the sample (those schools without any portable classrooms) were identified during data collection or follow-up of non-responding schools by telephone contact. Hence, the initial weight for each school found to be ineligible for the study because it had no portable classrooms was set to zero. This process resulted in setting the initial weight to zero for 48 of the 1,000 schools in the Phase I sample, including 36 of the 800 schools in the formaldehyde monitoring subsample. Hence, the CA PCS sample of 1,000 schools included 952 eligible schools, and the formaldehyde monitoring subsample of 800 schools included 764 eligible schools.

2.9.2 Adjustment for School-level Nonresponse

The first stage of nonresponse to the CA PCS occurred when eligible sample schools failed to provide the requested data. The numbers of schools that provided at least some of the requested questionnaire data was 426. We used the following information that was known for all 952 eligible sample schools to develop weighting classes to compensate for total questionnaire nonresponse at the school level:

1. School level (elementary/middle school/high school)
2. School location (urban/suburban/rural)
3. Northern vs southern California
4. Percent of children receiving AFDC
5. Percent of children receiving Federal meals assistance
6. Expenditure per student.

We performed a Chi-squared automatic interaction detection (CHAID) analysis using these data to determine the most significant predictors of whether or not the school provided questionnaire data. This tree algorithm partitioned the sample of 952 eligible schools into eight clusters that were most predictive of the school's questionnaire response status. Those clusters are defined in Table 2.6 and were used as weighting classes to adjust for school-level nonresponse.

Table 2.6. Weighting Classes

Weighting Class	Description	Number of Eligible Schools	Percent Responding Schools
1	School level = Elementary or High School; Percent on AFDC ≤ 0.481541	68	57.35
2	School level = Elementary or High School; Percent on AFDC > 29.5633	75	58.67
3	School level = Elementary or High School; 0.481541 < Percent on AFDC ≤ 29.5633 or missing; Expenditure per student < $5326.13	192	45.83
4	School level = Elementary or High School; 0.481541 < Percent on AFDC ≤ 29.5633 or missing; $5326.13 < Expenditure per student ≤ $5548.68	143	55.24
5	School level = Elementary or High School; 0.481541 < Percent on AFDC ≤ 29.5633 or missing; Expenditure per student > $5548.68	281	39.15
6	School level = Middle School; Expenditure per student ≤ $5447.39	82	31.71
7	School level = Middle School; Expenditure per student > $5447.39 or missing; Percent on federal meals assistance ≤ 55.7932 or missing	66	37.88
8	School level = Middle School; Expenditure per student > $5447.39 or missing; Percent on federal meals assistance > 55.7932	45	55.56

For each school in weighting class "c" the adjustment for questionnaire nonresponse was calculated as follows:

$$Adj(c) = \frac{\sum_{i \in c} w_1(i)\ I_e(i)}{\sum_{i \in c} w_1(i)\ I_r(i)}$$

where the summation is over all schools in weighting class "c," $w_1(i)$ is the initial weight for the i-th school, $I_e(i)$ is a (0,1)-indicator of whether or not the i-th school was eligible for the CA PCS, and $I_r(i)$ is a (0,1)-indicator of whether or not the i-th school provided any questionnaire data. When the initial weights are multiplied by these adjustment factors, the sum of the adjusted weights (P1WT6) for the responding schools in each weighting class is identical to the sum of the initial sampling weights (P1WT4) of all eligible schools.

For the formaldehyde subsample, formaldehyde data were obtained for at least one sample classroom for 320 of the 764 eligible schools. The same type of weighting class adjustment for school-level nonresponse was implemented for the formaldehyde subsample using the same weighting classes described in Table 2.6.

Of the 426 schools that provided some questionnaire data, 384 provided a completed FQ. Since the FQ includes school-level data, a statistical analysis weight was needed for these 384 schools that preserved the full sample totals. Hence, a further adjustment for school-level nonresponse was implemented using the same weighting classes described above but treating only the 384 schools with a completed FQ as the respondents. This resulted in the analysis weight, P1WT6FAC, which should be used for analysis of the school-level FQ data, Items 1-26 (Sections A and B).

2.9.3 Initial Classroom-level Weights

The initial classroom-level weights are the products of the school-level weights adjusted for school-level nonresponse and the reciprocals of the conditional classroom-level probabilities of selection. Since classrooms were selected using stratified simple random sampling (as implemented by the schools using instructions provided), the conditional weight for selecting classrooms was computed as

P1WT7 = N_p / n_p for portable classrooms
= N_t / n_t for traditional classrooms

where N_p and n_p are the total and sample numbers of portable classrooms at the school, respectively, and where N_t and n_t are the total and sample numbers of traditional classrooms at the school.

Initial sampling weights were calculated for the 1,272 sample classrooms selected at the 426 Phase I sample schools that provided at least some portion of the requested data. Likewise, among the 320 participating Phase I schools in the formaldehyde subsample, initial sampling weights were calculated for 956 sample classrooms.

2.9.4 Adjustment for Classroom-level Nonresponse

Among the 426 schools with some Phase I data, all possible patterns of classroom-level response occurred from completion of only one type of data (e.g., one Teacher Questionnaire) to completion of all types of data requested (i.e., the questionnaires and, if applicable, formaldehyde monitoring for all sample classrooms). Because some analyses will rely on data from only one source (e.g., Teacher Questionnaires) and others will require data from multiple sources (e.g., Facilities Questionnaire and formaldehyde monitoring), separate analysis weights were computed for each of the available sets of data sources. Weighting class weight adjustment procedures were used to adjust for classroom-level nonresponse. The adjustments were calculated using the same weighting classes described in Table 2.6 for school-level nonresponse, except that the adjustments were calculated separately for portable and traditional classrooms, which effectively doubled the number of weighting classes from eight to 16.

The final classroom-level statistical analysis weights and the set of respondents with which each weight variable should be used are summarized in Table 2.7.

Table 2.7. Classroom-level Analysis Weights

Analysis Weight	Type of Data Represented	Number of Respondents
P1WT10_1	Teacher Questionnaires	1,176
P1WT10_2	Facility Questionnaires	1,129
P1WT10_3	Formaldehyde Monitors	905
P1WT10_12	Both Teacher and Facility Questionnaires	1,072
P1WT10_13	Both Teacher Questionnaires and Formaldehyde Monitors	839
P1WT10_23	Both Facility Questionnaires and Formaldehyde Monitors	805
P1WT10_123	All three types of data	777

2.10 Statistical Analysis Methods

2.10.1 Formaldehyde Quality Control Analyses

Three types of QC data were obtained as a part of the formaldehyde sampling:

- Laboratory blanks
- Field blanks
- Duplicate field samples

Summary statistics were computed for the lab blanks—for both mass and uncorrected concentration measures (the latter assumed a one week exposure duration). The summary statistics included the mean, the standard deviation, and a limit of detection (LOD) based on the standard deviation. Summary statistics for the field blanks—for lab-blank corrected concentrations—included the mean, the standard deviation, and an LOD based on the standard deviation. For each pair of duplicate field measurements, a standard deviation (SD) and a relative standard deviation (RSD, expressed as SD/Mean x 100%) were determined. The distributions of these SDs and RSDs were then summarized using the following statistics:

- Pooled SD
- Median SD
- Maximum SD
- Mean RSD
- Median RSD
- Maximum RSD

These statistics were computed for all pairs and for all pairs where both measurements exceeded 6 ppb, the lab-based LOD.

The above statistics were computed using SAS macros (based on the SAS MEANS procedure). The results are discussed in Section 3.1.

2.10.2 Determination of Response Rates

Nonresponse to the CA PCS Phase I study occurs at two levels: schools and classrooms. Therefore, response rates were calculated at those same two levels. Since each sample unit has an analysis weight associated with it based on its probability of selection, both weighted and unweighted response rates were calculated. The weighted response rates are estimates of the response rates that would have been obtained if we had conducted a census of the population instead of a sample survey.

Within each level of study (schools and classrooms), nonresponse can occur for one or more types of data that were being collected. For example, for either a school or an individual classroom we may obtain TQs but not the FQ. Hence, at each level of study, response rates were calculated for each of the different types of data being collected and combinations thereof.

Each unweighted response rate is the number of schools or classrooms for which the particular response is obtained (e.g., Teacher Questionnaire) divided by the number of sample schools or classrooms that were eligible to provide those data. Hence, ineligible schools were removed from the denominator of the response rates, and formaldehyde monitoring response rates were calculated within the subsample of schools selected for formaldehyde monitoring.

Each weighted response rate is the sum of the initial sampling rates of the respondents divided by the sum of the same initial sampling weights over all eligible schools or classrooms. The sampling weights used to calculate the weighted response rates were the following:

1. P1WT4 = initial sampling weight for the 952 eligible schools in the full sample of 1,000 schools.
2. P1WT4PF1 = initial sampling weight for the 764 eligible schools in the subsample of 800 schools selected for formaldehyde monitoring.
3. P1WT8 = initial sampling weight for the 1,272 sample classrooms in the 426 schools with some questionnaire data.
4. P1WT8PF1 = initial sampling weight for the 956 sample classrooms in the 320 schools in the formaldehyde subsample with formaldehyde data for at least one classroom.

Using these weights, Table 2.8 describes how the weighted and unweighted school- and classroom-level response rates were calculated. The results are discussed in Section 3.2.

Table 2.8. Response Rate Calculations

Response Rate	Numerator	Denominator	Weight
Percent of eligible schools with TQ or FQ data	All sample schools with TQ or FQ data	All 952 eligible sample schools	P1WT4
Percent of eligible schools with FQ data	All sample schools with FQ data	All 952 eligible sample schools	P1WT4
Percent of eligible schools in the formaldehyde subsample with formaldehyde data	All sample schools with formaldehyde data for at least one classroom	All 764 eligible schools in the formaldehyde subsample	P1WT4PF1
Percent of classrooms with TQ data	All sample classrooms with TQ data	All 1,272 sample classrooms in the 426 schools that provided some questionnaire data	P1WT8
Percent of classrooms with FQ data	All sample classrooms with FQ data	All 1,272 sample classrooms in the 426 schools that provided some questionnaire data	P1WT8
Percent of classrooms with both TQ and FQ data	All sample classrooms with both TQ and FQ data	All 1,272 sample classrooms in the 426 schools that provided some questionnaire data	P1WT8
Percent of classrooms in the formaldehyde subsample with valid formaldehyde data	All sample classrooms with valid formaldehyde data	All 956 sample classrooms in the 320 schools in the formaldehyde subsample that provided formaldehyde data for at least one classroom	P1WT8PF1
Percent of classrooms in the formaldehyde subsample with valid formaldehyde and TQ data	All sample classrooms with valid formaldehyde and TQ data	All 956 sample classrooms in the 320 schools in the formaldehyde subsample that provided formaldehyde data for at least one classroom	P1WT8PF1
Percent of classrooms in the formaldehyde subsample with valid formaldehyde and FQ data	All sample classrooms with valid formaldehyde and FQ data	All 956 sample classrooms in the 320 schools in the formaldehyde subsample that provided formaldehyde data for at least one classroom	P1WT8PF1
Percent of classrooms in the formaldehyde subsample with valid formaldehyde, TQ, and FQ data	All sample classrooms with valid formaldehyde, TQ, and FQ data	All 956 sample classrooms in the 320 schools in the formaldehyde subsample that provided formaldehyde data for at least one classroom	P1WT8PF1

2.10.3 Estimation and Hypothesis Testing

Proper analysis of data collected for members of a probability sample requires that all observations be weighted inversely to their probabilities of selection. These sampling weights enable design-unbiased estimation of linear population parameters, such as population totals. As described in Section 2.9 above, initial sampling weights were developed as a part of the sample design activities, and, after data collection, these sampling weights were adjusted to compensate (at least partially) for the potential bias resulting from survey nonresponse. Weighting class adjustment procedures, for instance, were used in this study to make the adjustments. The paragraphs below indicate how the adjusted sampling weights were employed in making estimates of various population parameters.

A common example requiring weighted data analysis is estimation of a population proportion. For instance, for estimating a proportion P_x, the general form of the estimate is

$$\hat{P}_x = \sum w_i X_i / \sum w_i$$

where the summations are over all sample participants, where w_i denotes the sampling weight associated with classroom (or school) i, and where X_i is an indicator variable with a value of 1 if classroom (or school) i has the characteristic of interest and with a value of 0 otherwise. Note that the numerator is an estimate of the total number of classrooms (or schools) in the population having the characteristic, and the denominator is an estimate of the total number of classrooms (or schools) in the population. This type of estimate is used to characterize the population of eligible schools or classrooms. For instance, if X is set to 1 for all classrooms less than 3 years old, and to 0 otherwise, then the resultant estimated proportion is the proportion of the population estimated to be in that subgroup. Such estimates can also be used to characterize the population distribution of concentration levels over classrooms (e.g., by defining x to be 1 when a classroom has concentration exceeding some given threshold level).

If Y_i denotes a measured quantity for classroom (or school) i (e.g., the formaldehyde concentration), then a similar expression is used to estimate the target population's mean:

$$\overline{Y} = \sum w_i Y_i / \sum w_i$$

The numerator estimates the total of the Y variable that would have been obtained if all members of the target population had been observed, and, as before, the denominator estimates the total size of the target population.

Other study objectives involve estimating and comparing classroom concentrations for various domains (subpopulations) of the target population. Such domains are defined in terms of characteristics of the classrooms (or schools)—for example, classrooms in suburban areas. If proportions are to be estimated and compared, then the form of an estimated proportion for a domain d is

$$\hat{P}_x(d) = \sum w_i d_i X_i / \sum w_i d_i$$

where d_i = 1 if classroom i is in the domain d and d_i = 0 otherwise. Analogously, if means are to be estimated for such domains, then the form of the estimate is

$$\overline{Y}(d) = \sum w_i d_i Y_i / \sum w_i d_i$$

(Note that if the d_i are identically 1, then the domain of interest is the entire target population.)

A large portion of the data analysis for this study is based upon the above four estimation formulae. Estimates for all of the following, for example, were obtained either directly from one of the formulae or through application of some simple function to the estimates derived from the formulae (e.g., exponentiation of a log-scale mean to produce an estimated geometric mean):

- All tabulations and cross-tabulations of questionnaire items (from the same or different forms)
- Characteristics of overall formaldehyde concentration distributions
  - percent of population with levels > limit of detection (LOD)
  - proportion or percent of population with levels > specified guideline levels
  - overall arithmetic means and geometric means
  - selected percentiles (10^{th}, 25^{th}, 50^{th} [median], 75^{th}, 90^{th}, 95^{th}, 99^{th})
- Characteristics of formaldehyde concentration distributions for specific domains
  - percent of subpopulation with levels > limit of detection (LOD)
  - proportion or percent of subpopulation with levels > specified guideline levels
  - arithmetic means and geometric means for the domain
  - selected percentiles (10^{th}, 25^{th}, 50^{th} [median], 75^{th}, 90^{th}, 95^{th}, 99^{th}) for the domain.

In addition to estimating such population and domain parameters (e.g., proportions, means), it is important to estimate the precision of the estimate, which is usually expressed in terms of its variance or standard error. The estimation of sampling variances and standard errors for statistics calculated from probability sampling data should be based on the randomization distribution induced by the sampling design (i.e., they should account for all features of the sampling design, such as stratification and multistage sampling). Such an approach is robust because it makes no assumptions regarding the distribution of occurrence (e.g., normality) of the survey items. Hence, analyses based on the design-induced distribution provide the most defensible basis for making inferences from the sample to the target population.

The classic approach to estimating standard errors for nonlinear statistics, such as means and proportions, from complex probability sampling designs is a first-order Taylor Series linearization method, which was the method employed in this study. Alternative variance estimation techniques for such designs include jackknifing and balanced repeated replication. Standard statistical software packages (e.g., SAS, SPSS, BMDP, IMSL, etc.) do not typically include any of these algorithms for variance estimation. Therefore, special-purpose Survey Data Analysis (SUDAAN) software was used to analyze the survey data (RTI, 2001). SUDAAN estimates standard errors using the classical Taylor Series method because such estimates are both computationally and statistically efficient. The software includes procedures for survey-based estimation of standard errors of population totals, means, proportions, and ratios as well as linear and logistic regression relationships. RTI software for analysis of complex sample survey data has been reviewed by several non-RTI researchers and generally found to be the most efficient such software currently available. For means, proportions, differences in means, or differences in proportions, the precision is generally reported as an approximate 95% confidence interval calculated as the estimate +-2 times the standard error of the estimate.

The method for calculating measures of precision for percentiles is somewhat different. First, the percentile estimate (say, for the p^{th} percentile) is determined by forming a weighted cumulative empirical distribution and determining the point (say, X_p) at which the sum of the weights is 100p% of the total sum of the weights. A domain consisting of all observations with observed values less than X_p is then formed and the proportion of the population falling into this domain (approximately equal to p) is estimated as $\hat{p}$. The standard error of $\hat{p}$ is formed via the Taylor's Series method and a confidence interval for p is formed as $[\hat{p} - t_a s.e.(\hat{p}), \hat{p} + t_a s.e.(\hat{p})]$, where t_α is an appropriate tabulated t value. An inverse interpolation of the empirical cumulative distribution is then used to translate this interval into one for the percentile. That is, the lower confidence limit is that point L_p at which $100(\hat{p} - t_a s.e.(\hat{p}))\%$ of the total sum of the weights occurs, and the upper confidence limit is that point U_p at which $100(\hat{p} + t_a s.e.(\hat{p}))\%$ of the total sum of the weights occurs. This interval, $[L_p, U_p]$, forms an interval estimate for the p^{th} percentile; it is typically asymmetric about X_p,. The interval can be translated into a standard error by dividing the interval length (U_p-L_p) by $2t_\alpha$. Although such a standard error statistic cannot be used along with the estimated percentile to directly construct a confidence interval, it can be used to indicate the precision of one estimated percentile relative to another.

Approximate tests for certain types of hypotheses were also made using SUDAAN; such tests make use of the estimated proportions and their standard errors. For instance, to test that the proportion of portable classrooms in the target population with formaldehyde concentrations in excess of some threshold level C is the same as for traditional classrooms, we employed a t statistic such as:

$$t = \frac{\hat{P}_P - \hat{P}_T}{s.e.[\hat{P}_P - \hat{P}_T]}$$

where the numerator is the difference in the estimated proportions for portable (subscript P) and traditional (subscript T) classrooms and s.e. denotes the standard error of the estimated difference. A similar formula is used for comparing log-scale concentration means (where the difference in the Ps is replaced with the difference in the log-scale concentration means for portable and traditional classrooms). These types of tests assume that the estimate appearing in the numerator is approximately normally distributed.

In addition to the above types of tests, tests of association based on Wald chi-square statistics were also performed. In particular, these tests were used to determine if a particular factor was related to formaldehyde levels. In this case, weighted percentages (denoted as Ps below) estimated from the data are visualized in the form of a two-way table in which the factor of interest forms the rows, as illustrated below for a factor with three levels:

Factor of Interest	Classrooms with concentration<=C	Classrooms with concentration>C	Total
Level 1	P11	100-P11	100
Level 2	P21	100-P21	100
Level 3	P31	100-P31	100
Total	P1	P2	100

The test statistic performs a test of the hypothesis that the pair of proportions appearing in each row do not vary by row—that is, that the factor has no effect on the formaldehyde levels (as defined by the columns). Tests were performed both for all classrooms and for portable classrooms.

All of the above described estimates and tests were performed utilizing the SUDAAN procedures DESCRIPT and CROSSTAB.

Additional analyses involving modeling of the formaldehyde levels as functions of the questionnaire variates were performed using the SUDAAN procedure REGRESS. These analyses provide weighted analysis of variance (ANOVA) tests for the log-scale formaldehyde concentrations (variable LNMEAS). Two different types of models were fit:

Interaction model: LNMEAS=(Variable X) + ROOMTYPE + (Variable X)*ROOMTYPE

Main effects model: LNMEAS=(Variable X) + ROOMTYPE

The first model provides for a test of the interaction between ROOMTYPE (i.e., portable vs. traditional) and a given variable X (e.g., classroom age). The second model is appropriate if the interaction effect can be ignored; it provides for the tests of the main effects of the two variables appearing in the model. Results of these ANOVA tests are summarized by providing the p-values associated with the adjusted Wald F tests (see *SUDAAN User's Manual, Release 8.0* (2001)). These tests are analogous to the usual F tests used in classical ANOVAs.

The programs used to prepare the data for analysis and to perform the analyses are listed in Table 2.9. Documentation of the basic analysis files (SCHOOL1 and COMBIN4) is given in Appendix B and listings of the analysis programs are given in Appendix C. Details of SUDAAN procedures can be found in the *SUDAAN User's Manual, Release 8.0* (2001).

The results are discussed in Section 3.3.

Table 2-9. Summary of Programs Used to Analyze SCHOOL1 and COMBIN4 Data

Program	Input Files	Description	Output Files	Print Files (RTF)
1. RECODSCH	SCHOOL	Recode selected variables on SCHOOL file and create school-level analysis variables	SCHOOL1	
2. RECOD3_4	COMBIN3	Recode selected variables on COMBIN3 file and create classroom-level analysis variables	COMBIN4	
3. CRSLABVR	SLABVAR.TXT (user-supplied labels/formats)	Create file of labels and formats for school-level analysis variables	SLABVAR	SCHLABL
4. CRLABVAR	(user-supplied labels/formats)	Create file of labels and formats for classroom-level analysis variables	LABVAR	VARDEFS
5. RESPRATE	SCHOOL1 COMBIN4	Generate counts of eligible and responding schools and classrooms, and generate response rates		RESP_RAT
6. POPCHAR2	SCHOOL1	Generate population percentages for selected school level variables using SUDAAN PROC DESCRIPT	SCHPCT	POPCHAR2 (Appendix D)
7. POPCHAR1	COMBIN4 LABVAR	Generate population percentages for selected classroom level variables, overall and by classroom type, using SUDAAN PROC CROSSTAB; perform Wald chi-square tests to test for association of room type with selected variables	CLASPCT	POPCHAR1 (Appendix D)
8. WTDSTAT1	COMBIN4 LABVAR	Generate population estimates, via SUDAAN PROC DESCRIPT, for characterizing formaldehyde distributions, overall, by classroom type, and for domains defined by selected classroom level variables	OUTPCTL	POPESTS1 (Appendix E)
9. WTDSTATX	COMBIN4	Generate population estimates, via SUDAAN PROC DESCRIPT, for characterizing formaldehyde distributions, overall and by classroom type		POPESTSX (Table 3-12)
10. CDFPLOT	COMBIN4	Produce plots of distribution functions for formaldehyde concentrations, by classroom type		CDFPLOT
11. WTDTEST2	COMBIN4 LABVAR	Generate population percentages for selected classroom level variables for the subpopulation of portable classrooms and for all classrooms, using SUDAAN PROC CROSSTAB; perform Wald chi-square tests to test for association of variables with formaldehyde levels	PORTPCT ALLCPCT	POPTES2 (Appendix G)
12. PRNTAB1	PORTPC ALLCPCT	Print summary results from WTDTEST2 output		PRNTAB1 (Table 3-14)
13. COMPAR1	COMBIN4 LABVAR	Perform t tests, via SUDAAN PROC DESCRIPT, to compare portable versus traditional classrooms with respect to log(formaldehyde conc), overall and for domains defined by selected variables	COMPAR	COMPAR1 (Appendix F)
14. PRNTAB2	COMPAR	Print results from COMPAR1 output		PRNTAB2 (Table 3-13)
15. WTEDREG	COMBIN4	Perform regressions (ANOVAs) of log(conc) on room type and selected classroom level variables; generate adjusted Wald F statistics and p-values to test for association of variables with formaldehyde levels	WTDREG	
16. PRNTAB3	OUTPCTL WTDREG	Print results from WTEDTREG output		PRNTAB3 (Table 3-15)

3. RESULTS

Objectives of the Phase I data analysis are listed below, along with the subsection where results addressing each objective are presented:

1. To assess the quality of the formaldehyde concentration data (Section 3.1).
2. To assess quality of the survey data in terms of response rates (Section 3.2).
3. To characterize the population of Phase-I eligible schools (Section 3.3.1).
4. To characterize the population of Phase-I eligible classrooms, and to determine how characteristics of portable and traditional classrooms differ (Section 3.3.2).
5. To estimate distributions of classroom indoor-air formaldehyde concentrations, for portable and traditional classrooms, for the overall population of such classrooms and for selected subpopulations (domains) of such classrooms. (Section 3.4.1).
6. To compare portable and traditional classrooms with respect to indoor-air formaldehyde concentrations, for the overall population of such classrooms and for selected subpopulations (domains) of such classrooms. (Section 3.4.2).
7. To assess what factors (e.g., school type, school location) affect formaldehyde concentration levels in portable classrooms and in all classrooms (Section 3.4.3).

Weighted data analysis techniques are used in the analyses for objectives 3 through 7. Both weighted and unweighted response rate estimates (objective 2) were determined.

3.1 Formaldehyde QC Data

3.1.1 Limit of Detection and Laboratory Blanks

The sample masses and concentrations for the lab blanks (unexposed vials) are shown in the Table 3-1. The concentrations shown are not corrected for the mean of the lab blanks. Also shown is a non-detect (ND) indicator, which is 1 if the sample is considered a non-detect and is equal to 0, otherwise. The concentrations were generated under the assumption that T=168 hours (i.e., one week) and therefore are considered conservative (i.e., high) relative to the field samples which had a nominal sampling period of 240 hours. The 60 lab-blank analyses are grouped by lot number (i.e., two different groups of vials) and calibration date to form 6 groups of 10 runs; the listing within groups is sorted by concentration level. Only one of the 60 blanks resulted in a corrected concentration above 6 ppb, the detection limit reported by the laboratory.

Table 3-2 provides a summary of these data. It shows the mean ($\overline{X}_b$) and standard deviation of 10 blank-sample analyses for each of six cases. Note that drift over time did not appear to be significant.

Laboratory detection limits (in ppb) based on the standard deviations in Table 3-2 are as follows:

Calibration Date	Lot 180	Lot 181
4/24/01	6	4
5/23/01	13	6
6/15/01	8	4

These appear to be consistent with the lab-reported value of 6 ppb. They were computed by multiplying the standard deviations by 2.821, the 99th percentile of the t distribution having 9 degrees of freedom.

Table 3-1. Listing of Lab Blank Formaldehyde Data

	Lot Number 180			Lot Number 181		
Analysis Date	Sample ND Ind	Sample Mass (ug)	Uncorr. Conc (ppb)	Sample ND Ind	Sample Mass (ug)	Uncorr. Conc (ppb)
4/24/01	1	0.60	11.5	1	0.46	8.9
	1	0.67	12.8	1	0.49	9.5
	1	0.74	14.2	1	0.49	9.5
	1	0.75	14.6	1	0.52	10.0
	1	0.77	14.9	1	0.53	10.1
	1	0.80	15.4	1	0.53	10.3
	1	0.89	17.0	1	0.60	11.5
	1	0.89	17.2	1	0.61	11.8
	1	0.90	17.3	1	0.62	11.9
	1	0.99	19.1	1	0.71	13.6
5/23/01	1	0.60	11.5	1	0.37	7.0
	1	0.63	12.2	1	0.43	8.3
	1	0.66	12.7	1	0.44	8.5
	1	0.69	13.3	1	0.48	9.2
	1	0.73	13.9	1	0.49	9.5
	1	0.75	14.5	1	0.51	9.9
	1	0.84	16.1	1	0.54	10.4
	1	0.89	17.1	1	0.56	10.7
	1	0.91	17.5	1	0.61	11.8
	0	1.42	27.4	1	0.78	14.9
6/15/01	1	0.52	10.0	1	0.34	6.6
	1	0.53	10.2	1	0.38	7.2
	1	0.63	12.2	1	0.42	8.0
	1	0.70	13.4	1	0.47	9.0
	1	0.70	13.5	1	0.47	9.0
	1	0.76	14.6	1	0.50	9.5
	1	0.80	15.3	1	0.51	9.8
	1	0.90	17.3	1	0.52	10.0
	1	0.93	17.9	1	0.54	10.3
	1	0.96	18.5	1	0.57	10.8

Sample ND Indicator = 1 is sample is considered a non-detect.

Table 3-2. Summary of Laboratory Blanks

Lot Number	Analysis Date	Formaldehyde Mass in Blanks (µg)			Formaldehyde Uncorrected Concentration in Blanks (ppb)		
		Median	Mean	Std. Dev.	Median	Mean	Std. Dev.
180	4/24/01	0.79	0.80	0.12	15	15	2
180	5/23/01	0.74	0.81	0.24	14	16	5
180	6/15/01	0.73	0.74	0.16	14	14	3
181	4/24/01	0.53	0.56	0.08	10	11	1
181	5/23/01	0.50	0.52	0.11	10	10	2
181	6/15/01	0.48	0.47	0.07	9	9	1

Statistics in each row are based on 10 blank analyses. Concentrations are uncorrected.

3.1.2 Field Blanks

The sample masses and concentrations for the field blanks (unexposed vials sent to the field and returned without exposure) are shown in the Table 3-3, along with the ND indicators and data quality flags; rows are sorted by concentration level. Field blank data were obtained for 41 of 320 schools with formaldehyde data. Hence, the achieved rate was 12.8%, instead of the intended 15% rate.

The concentrations were generated under the assumption that the exposure times were equal to the exposure times reported for exposed tubes at the same school. Three of the 41 concentrations (7.3%) exceeded the 6ppb detection limit. The data for the 41 field blanks are summarized in Table 3-4. Note that the standard deviation for mass is 0.42, as compared to lab-blank standard deviations in the range of 0.07 to 0.24 (see Table 3-2). The detection limit based on the field blanks is 12 ppb, which is obtained by multiplying the field-blank standard deviation by 2.423, the 99th percentile of the t distribution having 40 degrees of freedom.

3.1.3 Duplicate Field Samples

Some schools were asked to provide duplicate samples for a given classroom. These duplicate sample data are listed in Table 3-5. Duplicate samples were obtained for one classroom in 67 of the 320 schools with formaldehyde data. Hence, the achieved rate was 20.9% instead of the intended 30% rate.

Table 3-5 includes the ND indicator, the data quality flag, and the concentrations for the field sample and its duplicate sample. The last two columns of Table 3-5 give, respectively, the standard deviation (SD) and relative standard deviation (RSD) of the paired measurements. These statistics can be used to characterize the overall measurement-error precision. Table 3-6 provides a summary of the distributions of these SDs and RSDs. Two situations are considered: all pairs (n=67), and all pairs where both members yielded a detectable amount (n=55). The median RSD is regarded as the most meaningful summary statistic among those shown. It indicates a 13.4% error for the first case and a 9.6% error for the second. A number of the cases

Table 3-3. Listing of Field Blank Formaldehyde Data

Study ID	Sample ND Ind	Sample Mass (ug)	Sample Conc (ppb)	Sample Data Quality Ind
2060	1	0.31	-4.0	0
2267	1	0.34	-3.4	0
2018	1	0.31	-2.8	0
2178	1	0.34	-2.4	0
1059	1	0.66	-2.2	1
1326	1	0.58	-2.2	0
2191	1	0.37	-2.1	0
1319	1	0.33	-2.1	1
1406	1	0.36	-2.1	0
2099	1	0.37	-2.1	0
2474	1	0.32	-2.0	0
1371	1	0.43	-1.9	0
1492	1	0.35	-1.9	0
1274	1	0.40	-1.8	1
2294	1	0.43	-1.6	1
1130	1	0.70	-1.6	0
2248	1	0.40	-1.6	0
2226	1	0.33	-1.5	0
1185	1	0.71	-1.5	0
1496	1	0.41	-1.1	0
1203	1	0.70	-0.9	0
1374	1	0.41	-0.8	0
2495	1	0.39	-0.8	0
1491	1	0.78	-0.2	0
1144	1	0.78	-0.2	0
1052	1	0.83	0.2	0
1281	1	0.84	0.6	0
1127	1	0.89	1.1	0
1507	1	0.92	1.6	0
1500	1	0.91	1.9	0
1021	1	0.94	2.0	0
2101	1	0.66	2.0	0
1026	1	0.96	2.3	1
1005	1	0.93	2.9	0
1155	1	1.02	3.0	0
1170	1	1.08	3.5	0
2213	1	0.74	3.9	0
1573	1	0.83	4.7	1
2139	0	1.03	8.7	0
1506	0	1.95	17.1	0
1078	0	2.33	20.6	1

Sample ND Indicator = 1 when result is considered a non-detect.
Data quality Indicator = 1 if some problems encountered in field or lab, = 0 otherwise.

Table 3-4. Summary of Formaldehyde Mass and Concentration in Field Blanks

Variable	n	Mean	Median	Std Dev	Minimum	Maximum
Formaldehyde Mass (ug)	41	0.69	0.66	0.42	0.31	2.33
Formaldehyde Conc. (ppb)	41	0.77	-0.85	4.89	-3.95	20.65

Table 3-5. Listing of Duplicate Field Sample Formaldehyde Concentrations (ppb)

Study ID	Class ID	Field Sample ND Ind	Dup Sample ND Ind	Field Sample Conc (ppb)	Dup Sample Conc (ppb)	Field Sample Data Quality Ind	Dup Sample Data Quality Ind	Std. Dev. (ppb)	Rel. Std. Dev. (%)
1007	B	0	0	9.064	16.619	0	1	5.3421	41.599
1009	C	0	0	27.905	31.978	0	0	2.8803	9.620
1028	C	0	0	47.843	21.412	0	0	18.6892	53.972
1031	B	0	1	47.555	0.100	1	1	33.5561	140.828
1041	B	0	0	58.254	60.546	0	0	1.6204	2.728
1050	C	0	0	16.704	13.398	0	0	2.3378	15.533
1058	A	0	0	15.300	15.300	0	0	0.0000	0.000
1073	C	0	0	37.929	37.308	0	1	0.4391	1.167
1075	B	0	0	27.438	23.644	0	0	2.6824	10.502
1106	B	0	0	23.557	29.932	0	0	4.5080	16.856
1125	A	0	0	21.463	26.568	0	0	3.6100	15.032
1132	A	0	0	18.530	12.778	0	0	4.0670	25.981
1142	B	0	0	20.303	24.506	0	0	2.9722	13.266
1143	A	0	0	11.207	15.663	0	0	3.1512	23.455
1146	A	0	0	46.030	41.578	0	0	3.1477	7.186
1174	B	0	0	28.999	39.227	0	0	7.2319	21.200
1183	B	0	0	41.323	39.566	1	0	1.2420	3.071
1189	A	0	0	29.230	27.486	0	0	1.2329	4.348
1201	A	0	1	41.073	2.101	0	0	27.5577	127.660
1225	C	0	1	17.899	2.196	0	0	11.1034	110.509
1227	A	1	0	5.854	8.350	0	0	1.7650	24.852
1231	A	0	0	97.133	92.660	0	0	3.1629	3.333
1239	A	0	0	23.034	25.590	0	0	1.8068	7.432
1252	A	0	1	64.072	3.187	0	1	43.0526	128.021
1264	B	0	1	58.141	0.100	0	0	41.0412	140.936
1277	B	0	0	26.130	21.940	1	1	2.9629	12.327
1284	C	0	0	26.200	27.963	0	0	1.2464	4.602
1285	C	0	0	34.467	65.492	0	0	21.9380	43.894
1290	C	0	0	21.131	12.227	0	0	6.2967	37.752
1364	A	0	0	77.632	77.308	0	0	0.2292	0.296
1383	B	0	0	12.972	17.338	0	0	3.0877	20.375
1402	C	0	0	10.584	13.347	0	0	1.9544	16.333
1429	A	0	1	27.238	1.866	0	0	17.9404	123.287
1435	A	0	0	17.827	21.329	0	0	2.4764	12.649
1442	C	0	1	40.952	0.100	0	0	28.8866	140.732
1457	C	0	0	16.286	11.987	0	0	3.0399	21.504
1459	B	0	0	19.782	18.220	0	0	1.1050	5.815
1460	B	0	0	23.086	25.496	0	0	1.7039	7.015
1463	B	0	0	33.225	25.083	0	0	5.7573	19.748
1479	C	0	0	10.345	16.328	0	0	4.2307	31.722
1484	A	0	0	48.438	32.467	0	1	11.2932	27.917
1494	C	0	0	40.080	51.110	0	0	7.8000	17.107
1504	C	0	0	11.562	13.982	0	0	1.7114	13.399
1508	A	0	0	70.260	53.916	0	0	11.5573	18.614
1527	A	0	0	16.696	18.574	0	0	1.3274	7.527
1584	A	0	0	101.266	109.386	0	0	5.7417	5.451
1585	B	0	1	27.117	2.220	0	0	17.6042	120.013
2002	B	0	0	16.007	16.758	0	0	0.5310	3.241
2022	B	0	0	32.568	38.075	0	0	3.8939	11.024
2047	B	0	1	38.035	1.036	0	0	26.1624	133.920
2051	A	0	0	25.010	14.362	0	0	7.5294	38.248
2065	A	0	0	20.710	20.594	0	0	0.0820	0.397
2104	B	0	0	39.517	34.930	0	0	3.2431	8.713

Study ID	Class ID	Field Sample ND Ind	Dup Sample ND Ind	Field Sample Conc (ppb)	Dup Sample Conc (ppb)	Field Sample Data Quality Ind	Dup Sample Data Quality Ind	Std. Dev. (ppb)	Rel. Std. Dev. (%)
2165	A	0	0	30.909	31.809	0	0	0.6366	2.030
2166	B	0	0	74.018	75.299	1	0	0.9057	1.213
2167	B	0	0	61.188	63.869	0	0	1.8958	3.032
2172	C	0	0	39.148	38.421	0	0	0.5145	1.327
2193	A	0	0	86.565	78.500	1	0	5.7028	6.910
2251	C	0	0	36.414	33.567	0	0	2.0134	5.754
2284	C	0	1	38.661	0.100	0	0	27.2671	140.692
2288	A	0	0	51.575	67.117	0	0	10.9900	18.518
2335	A	0	0	49.387	54.094	0	0	3.3281	6.432
2369	B	0	1	21.270	0.100	0	0	14.9693	140.098
2411	C	0	0	37.614	38.627	0	0	0.7165	1.880
2422	A	0	0	41.174	37.877	0	0	2.3313	5.898
2441	A	0	0	39.046	39.875	0	0	0.5859	1.485
2449	C	0	0	40.998	50.936	0	1	7.0276	15.288

Sample ND Indicator = 1 when result is considered a non-detect.
Data quality Indicator = 1 if some problems encountered in field or lab, = 0 otherwise.

Table 3-6. Summary of Standard Deviations and RSDs for Duplicate Field Samples

Cases	No. Pairs	Pooled Std. Dev.	Median Std. Dev.	Maximum Std. Dev.	Mean RSD(%)	Median RSD(%)	Maximum RSD(%)
All pairs	67	12.52	3.151	43.05	32.9	13.4	140.9
All pairs with both detected	55	5.777	2.963	21.94	13.3	9.6	54.0

where large RSDs occur (see Table 3-5) appear to be cases in which one member of the pair might not have been exposed. Another possible explanation for a large RSD is that the duplicate vial might not actually have been exposed in the same room as the primary sample.

A more intensive review of the 10 data pairs when at least one of the concentration values was above 60 ppb and both values were above the LOD indicates that 9 pairs (90%) had differences less than 20 ppb. (20 ppb is the highest field blank observed, taken from Table 3.3.) In addition, 7 of the 10 pairs (70%) had an RSD less than 10%, which is extremely good for a passive monitor. This suggests that decisions based on which classrooms had relatively high formaldehyde concentrations during the sampling period are based on good QC information. A similar review of the 29 data pairs when at least one of the concentration values was above 30 ppb and both values were above the LOD indicates that 27 pairs (93%) had differences less than 20 ppb. In addition, 19 of the 29 data pairs (66%) had an RSD less than 10%. Again, the good QC results provide a measure of confidence when performing further statistical analysis of the data.

3.2 Response Rates

School-level response rates for Phase I of the CA PCS are shown in Table 3-7 by school characteristics known for both responding and nonresponding schools:

1. School level (elementary/middle school/high school)
2. School location (urban/suburban/rural)
3. Northern vs. southern California
4. Percent of children receiving AFDC
5. Percent of children receiving Federal meals assistance
6. Expenditure per student.

Of the full sample of 1,000 CA public schools, 952 were eligible for the study (i.e., had at least one portable classroom), and 426 of these schools provided at least some questionnaire data, resulting in a overall school-level response rate of 44.7%. Of the categories shown in Table 3-7, the lowest response rate (38.9%) occurred for middle schools and the highest (48.8%) occurred school-level for schools with over 25% of their students receiving AFDC support.

Since some Facilities Questionnaire data items are school-level items (namely Items 1-26, Sections A and B), it is also informative to note that Facilities Questionnaires were received for 384 of the 952 eligible schools, resulting in a 40.3% response rate for the Facilities Questionnaire.

In the formaldehyde subsample of 800 schools, 764 were eligible for the study. Of these schools, 320 completed formaldehyde monitoring for at least one classroom, producing a school-level response rate of 41.9%.

Table 3-8 provides the raw numbers of sample classrooms and classrooms with questionnaire data among the 426 participating schools in the full sample. It also provides the numbers of classrooms with formaldehyde and questionnaire data among the 320 schools with at least some formaldehyde data. We see that the 426 participating schools in the full sample

Table 3-7. Number of Eligible and Responding Schools and School-Level Response Rates

Classification	Category	No. Eligible Schools	No. Responses TQ or FQ Data	School Level Response Rate	No. Responses FQ Data	FQ School Response Rate	No. Eligible Schools H2CO Subsample	No. Responses H2CO Data	H2CO Subsample School Response Rate
Overall		952	426	44.7	384	40.3	764	320	41.9
School Type	Elem	565	261	46.2	232	41.1	456	205	45.0
	Middle	193	75	38.9	68	35.2	151	54	35.8
	High	194	90	46.4	84	43.3	157	61	38.9
School Location	Urban	164	72	43.9	59	36.0	124	51	41.1
	Suburb	703	315	44.8	287	40.8	572	239	41.8
	Rural	85	39	45.9	38	44.7	68	30	44.1
Geographic Region	North	430	189	44.0	178	41.4	348	141	40.5
	South	522	237	45.4	206	39.5	416	179	43.0
% AFDC	<=25%	804	354	44.0	316	39.3	650	267	41.1
	>25%	127	62	48.8	58	45.7	96	44	45.8
% Meal Assist	<=55%	554	240	43.3	214	38.6	451	178	39.5
	>55%	377	176	46.7	160	42.4	295	133	45.1
Per Student Expend	<=$5500	427	200	46.8	180	42.2	342	148	43.3
	>$5500	525	226	43.0	204	38.9	422	172	40.8

Table 3-8. Number of Eligible and Responding Classrooms

Classification	Category	No. Eligible Clrooms	No. Responses TQ Data	No. Responses FQ Data	No. Responses TQ & FQ Data	No. Eligible Clrooms H2CO Subsample	No. Responses H2CO Data	No. Responses H2CO & TQ Data	No. Responses H2CO & FQ Data	No. Responses H2CO & TQ & FQ Data
Overall		1272	1181	1133	1077	956	911	844	810	782
School Type	Elem	783	738	691	666	615	592	539	515	495
	Middle	224	203	201	187	161	149	138	133	127
	High	265	240	241	224	180	170	167	162	160
School Location	Urban	216	196	175	168	153	147	121	110	104
	Suburb	942	877	851	804	716	684	645	620	600
	Rural	114	108	107	105	87	80	78	80	78
Geographic Region	North	561	504	516	477	419	397	371	368	351
	South	711	677	617	600	537	514	473	442	431
% AFDC	<=25%	1058	984	932	890	799	762	716	677	660
	>25%	184	171	171	161	130	123	103	107	97
% Meal Assist	<=55%	714	658	624	597	530	509	480	459	448
	>55%	528	497	479	454	399	376	339	325	309
Per Student Expend	<=$5500	600	563	535	512	444	421	402	380	372
	>$5500	672	618	598	565	512	490	442	430	410
Room Type	Port	907	844	812	767	676	644	598	574	555
	Trad	365	337	321	310	280	267	246	236	227

generated 1,272 sample classrooms and that both Teacher and Facilities Questionnaire data are available for 1,077 of these classrooms. Likewise, we see that the 320 schools in the formaldehyde subsample with formaldehyde data for at least one classroom generated 956 sample classrooms and that formaldehyde data were obtained in addition to Teacher and Facilities Questionnaires for 782 of these classrooms. We also see that the full sample contained 907 portable classrooms and 365 traditional classrooms. Moreover, formaldehyde data were obtained for 644 portable classrooms and 267 traditional classrooms.

The ratios of the numbers of classrooms with data divided by the corresponding numbers of eligible classrooms in Table 3-8 result in the unweighted conditional classroom-level response rates shown in Table 3-9. However, the sample classrooms do not all have the same initial sampling rate because of random selection of a fixed number of classrooms from each school. Hence, weighted conditional response rates also were calculated by summing the initial sampling weights of the participating classrooms and dividing by the sum of the initial sampling weights for all sample classrooms. Those weighted conditional classroom-level response rates are shown in Table 3-10. The weighted response rates can be interpreted as the predicted response rate that would have occurred if all classrooms had been selected at the participating schools (and the additional school-level participant burden was not a factor).[5] We see that the weighted conditional response rates, given school-level participation, are quite good: 93.6% for the Teacher Questionnaire; 87.3% for the Facilities Questionnaire; and 95.6% for formaldehyde monitoring. The conditional response rate shrinks to 82.5% for provision of all three types of data (Teacher Questionnaire, Facilities Questionnaire, and formaldehyde data) in the formaldehyde subsample. In addition, we see that the response rate is essentially the same for portable and traditional classrooms. For example, the conditional Teacher Questionnaire response rates are 93.8% and 93.5% for portable and traditional classrooms, respectively.

Table 3-11 shows the products of the school-level response rates from Table 3-7 and weighted conditional classroom-level response rates in Table 3-10, which are the overall study response rates. That is, these are the proportions of the classrooms in the full target population of CA public classrooms in schools with portable classrooms in Spring 2001 that are directly represented by the responding classrooms. We see that the overall response rate is 41.9% for the Teacher Questionnaire, 39.1% for the Facilities Questionnaire, and 40.1% for formaldehyde data. However, the overall response rate drops to 34.5% for joint response to both questionnaires and formaldehyde monitoring. These relatively low response rates introduce some potential for nonresponse bias. However, the weight adjustments described in Section 2.9 were implemented to reduce the nonresponse bias using data known for both responding and nonresponding schools.

These response rates are not atypical for mail surveys. Dillman (2000, pg. 323) reports that a review of 183 business surveys conducted by mail (based on publications between 1990 and 1992) revealed an average response rate of 21%. However, Dillman (2000, p. 331) also cites five mail surveys of businesses with telephone follow-up of nonrespondents that achieved response rates from 67% to 83%.

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[5] The unweighted response rates are only sample statistics and have no direct interpretation regarding the population.

Table 3-9. Unweighted Conditional Classroom-Level Response Rates

Classification	Category	Clroom TQ Response Rate	Clroom FQ Response Rate	Clroom TQ&FQ Response Rate	Clroom H2CO Response Rate	Clroom H2CO&TQ Response Rate	Clroom H2CO&FQ Response Rate	Clroom H2CO& TQ&FQ Response Rate
Overall		92.8	89.1	84.7	95.3	88.3	84.7	81.8
School Type	Elem	94.3	88.3	85.1	96.3	87.6	83.7	80.5
	Middle	90.6	89.7	83.5	92.5	85.7	82.6	78.9
	High	90.6	90.9	84.5	94.4	92.8	90.0	88.9
School Location	Urban	90.7	81.0	77.8	96.1	79.1	71.9	68.0
	Suburb	93.1	90.3	85.4	95.5	90.1	86.6	83.8
	Rural	94.7	93.9	92.1	92.0	89.7	92.0	89.7
Geographic Region	North	89.8	92.0	85.0	94.7	88.5	87.8	83.8
	South	95.2	86.8	84.4	95.7	88.1	82.3	80.3
% AFDC	<=25%	93.0	88.1	84.1	95.4	89.6	84.7	82.6
	>25%	92.9	92.9	87.5	94.6	79.2	82.3	74.6
% Meal Assist	<=55%	92.2	87.4	83.6	96.0	90.6	86.6	84.5
	>55%	94.1	90.7	86.0	94.2	85.0	81.5	77.4
Per Student Expend	<=$5500	93.8	89.2	85.3	94.8	90.5	85.6	83.8
	>$5500	92.0	89.0	84.1	95.7	86.3	84.0	80.1
Room Type	Port	93.1	89.5	84.6	95.3	88.5	84.9	82.1
	Trad	92.3	87.9	84.9	95.4	87.9	84.3	81.1

Table 3-10. Weighted Conditional Classroom-Level Response Rates

Classification	Category	Clroom TQ Response Rate	Clroom FQ Response Rate	Clroom TQ&FQ Response Rate	Clroom H2CO Response Rate	Clroom H2CO&TQ Response Rate	Clroom H2CO&FQ Response Rate	Clroom H2CO& TQ&FQ Response Rate
Overall		93.6	87.3	84.2	95.6	88.7	85.2	82.5
School Type	Elem	93.5	86.8	83.8	95.7	86.6	82.4	79.0
	Middle	88.7	87.0	81.5	91.4	81.1	78.8	73.9
	High	97.2	88.5	86.8	98.4	98.0	95.3	95.2
School Location	Urban	88.8	79.9	75.9	94.9	73.4	67.8	61.1
	Suburb	95.0	89.0	85.9	96.2	92.1	88.7	86.7
	Rural	93.8	92.3	91.4	91.1	90.1	91.1	90.1
Geographic Region	North	90.9	90.6	85.0	95.8	87.9	88.8	83.3
	South	95.2	85.4	83.7	95.5	89.2	83.1	82.0
% AFDC	<=25%	93.4	86.1	83.2	95.6	89.4	85.2	82.9
	>25%	93.9	93.0	88.5	95.0	80.4	82.5	75.4
% Meal Assist	<=55%	92.8	85.0	82.5	97.4	91.7	88.7	86.6
	>55%	94.5	90.0	86.1	92.7	83.4	79.0	75.1
Per Student Expend	<=$5500	93.6	87.6	84.7	93.9	89.8	85.8	83.9
	>$5500	93.6	87.1	83.8	97.1	87.7	84.8	81.3
Room Type	Port	93.8	89.0	85.0	95.5	88.1	85.1	82.7
	Trad	93.5	86.4	83.8	95.7	89.0	85.3	82.4

Table 3-11. Weighted Overall Classroom-Level Response Rates

Classification	Category	Clroom TQ Response Rate	Clroom FQ Response Rate	Clroom TQ&FQ Response Rate	Clroom H2CO Response Rate	Clroom H2CO&TQ Response Rate	Clroom H2CO&FQ Response Rate	Clroom H2CO& TQ&FQ Response Rate
Overall		41.9	39.1	37.7	40.1	37.1	35.7	34.5
School Type	Elem	43.2	40.1	38.7	43.0	39.0	37.0	35.5
	Middle	34.5	33.8	31.7	32.7	29.0	28.2	26.4
	High	45.1	41.1	40.3	38.2	38.1	37.0	37.0
School Location	Urban	39.0	35.1	33.3	39.0	30.2	27.9	25.1
	Suburb	42.5	39.9	38.5	40.2	38.5	37.1	36.2
	Rural	43.0	42.3	42.0	40.2	39.7	40.2	39.7
Geographic Region	North	40.0	39.8	37.4	38.8	35.6	36.0	33.8
	South	43.2	38.8	38.0	41.1	38.4	35.8	35.3
% AFDC	<=25%	41.1	37.9	36.6	39.3	36.7	35.0	34.0
	>25%	45.8	45.4	43.2	43.5	36.9	37.8	34.5
% Meal Assist	<=55%	40.2	36.8	35.7	38.4	36.2	35.0	34.2
	>55%	44.1	42.0	40.2	41.8	37.6	35.6	33.9
Per Student Expend	<=$5500	43.8	41.1	39.7	40.6	38.9	37.1	36.3
	>$5500	40.3	37.5	36.1	39.6	35.8	34.6	33.1
Room Type	Port	42.0	39.8	38.0	40.0	36.9	35.7	34.6
	Trad	41.8	38.7	37.5	40.1	37.3	35.7	34.5

3.3 Characterization of the Target Population

As discussed in Section 2.4.1, the target population for this study consists of all of California's K-12 public schools with at least one portable classroom in the Spring of 2001, including special districts operated by the counties. Hence, all portable classrooms being used in the Spring of 2001 are included, but traditional classrooms at schools with no portable classrooms are not included.

The target population for the Phase I study is estimated to consist of 6,924 schools and 230,156 classrooms.[6] Of these classrooms, 85,416 (or 37.1%) are estimated to be portable classrooms. Section 3.3.1 highlights some of the characteristics of the school population, while Section 3.3.2 highlights characteristics of the classroom population. Detailed summary statistics upon which these results are based are given in Appendix D.

The sample of 1,000 schools selected for the Phase I mailed survey is representative of all schools in the target population described above because the sample was randomly selected from all schools on the California Public Schools Directory 2000. The California Department of Health Services selected an initial systematic sample of 1,216 schools. They conducted a preliminary survey which determined that 177 schools (14.6%) were ineligible for the study (had no portable classrooms). In addition, 48 of the 1,000 schools which were randomly selected for Phase I were ineligible. Therefore, about 19.4% (14.6% + 4.8%) of California public schools had no portable classrooms in the Spring of 2001, and those schools are not represented in this study.

3.3.1 School-Level Results

The distributions of the target population schools showed the following:

- The majority of schools are in the suburbs (73.8%); only 8.9% are in rural areas.
- The southern region[7] accounted for 54.8% of the schools.
- 59.3% of the schools were elementary; the remaining 40.7% were split equally among middle and high schools.
- A minority (13.6%) of the schools has more than 25% of their students on AFDC, but about 40.5% of the schools have 55% or more of their students on Federal meal assistance programs.
- 55.1% of the schools are estimated to spend more the $5500 per student.

Based on responses to the FQ, the following additional characteristics were estimated:

- Over half (54.4%) of the schools are estimated to have 10 or fewer portable classrooms, but 4.4% are estimated to have over 30 portable classrooms.
- Less than 35% of the facility managers (FMs) were aware of the EPA IAQ Tools for Schools Program and less than 11% actually made use of the program.

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[6] In comparison, the estimate from the DHS preliminary survey of all districts in the state is approximately 80,500 portable classrooms.
[7] See Figure 2-1.

- Among schools for which an age was known (90.4%), about 29% were reported to be less than 30 years old.
- 52.1% of the FMs received some major environmentally-related complaints in the past year.
- The percentages of schools with one or more reported complaints in the past year were as follows:

Classroom Type	Roof Leaks	Plumbing Leaks	Air Quality/Odor	Mold	Temperature	Noise
Portable	60.9	20.4	51.2	25.5	50.0	19.7
Traditional	44.2	30.1	31.0	16.3	40.9	14.8

These school-based results must be interpreted with caution because of differences in the numbers of portable and traditional classrooms in the schools and because of differences in the reported frequencies of complaints for the two types of classrooms. It is more appropriate to compare the classrooms using the classroom-level data.

3.3.2 Classroom-Level Results

About 2/3 of the classrooms in the target population were in suburban areas, with 6.8% in rural areas and 15.9% in urban areas. There was not a statistically significant difference[8] in this distribution for portable versus traditional rooms. The same was true for the north-versus-south regions. However, a larger percentage of elementary school classrooms in the target population are portable: 57.5% of the portable classrooms were in elementary schools, as compared to 45.9% of the traditional classrooms.

TQ Data. There were 1181 responses to the teacher questionnaire; 1169 of these provided a room type description, distributed as follows:

Room description	Portable	Traditional	Total
General instruction class	754	285	1039
Art room	2	3	5
Science lab	14	17	31
Computer lab	10	6	16
Wood shop	0	4	4
Library	10	4	14
Auto/metal shop	0	1	1
Music room	8	1	9
Office	5	3	8
None of above	26	7	33
Multiple responses	6	3	9

[8] A difference is declared to be statistically significant at a given significance level if the observed difference is larger than would be expected to occur by chance when the null hypothesis of no difference is true. Significance probabilities are reported as p-values. A small p value thus indicates a significant difference.

Thus, the vast majority of the rooms are general instruction classrooms. The weighted percentages of classrooms that are general instruction classrooms were 90.4% and 75.1%, for portable and traditional rooms, respectively, a statistically significant difference.

Portable versus traditional classroom differences were detected as statistically significant for a number of the TQ items (see Appendix D for a complete listing); a significance level of 0.01 applies unless otherwise indicated:

- Floor type: portable classrooms had a higher percentage of carpeted floors (70.7% full carpet, versus 34.3% for traditional classrooms) and a lower percentage of vinyl/linoleum floors (29.3% vs. 55.3%)
- Wall materials: A much higher percentage portable classrooms had vinyl tackable wallboard. (78.6% vs. 28.4%)
- Open windows and exterior doors: A smaller percentage of portable classrooms have windows that will not open than do traditional classrooms (13.0% vs. 34.1%), but portable classrooms have exterior doors that open more often than do traditional classrooms (99.9% vs. 76.8%).
- HVAC use: A higher percentage of portable classrooms are air conditioned (95.4% vs. 77.1%) and have a thermostat (that is adjustable) in the room (77.4% vs. 49.9%).
- A higher percentage of the portable rooms make use of the following: paints/pens ($p=0.03$), air fresheners ($p=0.04$), and pesticide powders ($p=0.01$). Candles were used more frequently in traditional classrooms ($p=0.01$).
- Teachers from traditional classrooms show a high preference for traditional over portable classrooms, with 84% preferring the former, but only 34.7% of the teachers from portable classrooms prefer traditional classrooms and 30.1% of these teachers actually prefer portable classrooms.
- Teachers in portable classrooms are more often satisfied with air temperatures than those in traditional rooms (78.1% vs. 65.1%), but they also more frequently found the air to be stuffy (44.7% vs. 33.4%) and the lighting to be poor (27.5% vs. 13.0%).
- Portable-classroom teachers more often reported disruptive noise inside ($p=0.03$), and they more often (60.1 vs. 23.0%) reported that they turned off HVAC systems due to excessive noise.
- Portable-classroom teachers reported more musty odors and more new carpet/furnishing odors than did traditional-classroom teachers; they reported fewer cleaning products ($p=0.03$), cooking, and new paint odors.
- Portable-classroom teachers reported less construction within the same building, probably because portable classrooms are newer, and the building envelope is more confined, i.e., there is less area, in the case of the portable classroom.
- Roof leaks or floods appeared more prevalent for portable classrooms, while other types of leaks appeared more prevalent for traditional rooms ($p = 0.01$).

	Type of Leak		
	Roof	Other	Both
Portable	26.9	8.3	7.1
Traditional	20.1	17.6	8.0

Some important factors for which no differences between portable and traditional rooms were reported by teachers are the following: class size, types of furniture and appliances, pest problems (rodents and bugs) and pesticide use (by teacher) and odors, most other types of odors (except for those noted above), construction activity, water problems (except as noted above), and frequency of cleaning activities. In addition, teacher satisfaction with custodial activities and environmental air quality was about the same for both types of teachers. Both types complained about the same amount regarding odors, temperature, and hygiene in their rooms. Both types reported about the same amount of teacher absenteeism and health-related symptoms, although there was some indication of slightly higher levels of nose-, throat-, and skin-related symptoms for portable-classroom teachers ($p=0.05$, 0.06, and 0.06, respectively).

Some other TQ items were marginally significant (see Appendix D). Also several other important indoor environmental quality factors from the TQ were not significantly different between portable and traditional classrooms, but their general prevalence rates are notable. For example:

- various indicators of potential moisture problems were in about 20% of the rooms, but visible mold in only 3%
- indoor pollutant sources such as new pressed wood, paint, and flooring, and pesticide use were each present in about 20-30% of the rooms.

FQ Data. Facility manager data on classrooms revealed some important differences between the portable and traditional rooms. Age of the room is one major difference. The age is known (for both types) for only about 2/3 of the rooms, but among those for which it is known, an estimated 55.3% of the portables are 10 years old or less, while only 12.4% of the traditional rooms are that new. On the other hand, major renovations/additions have occurred more often in the traditional rooms (47.7% vs 23.7% in portables). Size of the classrooms is another major difference: only 23.5% of the portable rooms exceed 1100 square feet, whereas 36.7% of the traditional rooms do. Portables and traditionals differ in several structural ways: floor height, roof type, and ceiling style (dropped ceiling). HVAC differences also occur:

Type: 80.8% packaged HVAC in portables; 62.9% in traditionals
Location: 81.4% wall air handling units (AHUs) in portables; 31.6% in traditionals
Supply Fan Operation: 78.1% automatic in portables; 65.2% in traditionals
Plenum: 28.4% open in portables; 16.2% in traditionals
Thermostat control: 45.1% via teachers in portables; 26.8% in traditionals.

Estimated frequencies of classroom problems reported by Facility Managers for the past 3 years were as follows (no statistically significant differences between portables and traditionals):

	Water Damage	Roof Leaks	Visible Mold
Portable	22.9%	19.4%	4.9%
Traditional	23.9%	19.9%	3.1%

3.4 Analysis of Formaldehyde Concentration Data

Classroom concentrations of formaldehyde generally cannot be lower than the concentration in ambient outdoor air because of indoor sources. Outdoor air levels of formaldehyde average about 3 ppb in California cities based on 24-hour measurements from 1997 through 2000 (ARB, 2001). Outdoor levels over 24 hours can reach as much as 20 ppb in areas near outdoor sources, such as heavy traffic locations. Hence, classroom concentrations from 3 ppb to 20 ppb may not be elevated above outdoor levels.

3.4.1 Distribution of Concentrations

Usable Phase I H_2CO concentration data were available for 911 classrooms—644 portable classrooms and 267 traditional classrooms. These data, coupled with appropriate sampling weights, were used to generate estimates of population parameters that characterize the distributions of H_2CO levels. Estimates were generated for all eligible classrooms and for two subpopulations of these: portable and traditional. The distributions were characterized in terms of the statistics shown in the left-most column of Table 3-12; in addition to the sample size and the estimated population size, these included:

- percentage of population with H_2CO concentration >6, 27, and 76 ppb
- measures of central tendency (mean, median, geometric mean)
- selected percentiles (5^{th}, 10^{th}, 25^{th}, 50^{th} [median], 75^{th}, 90^{th}, 95^{th})

Table 3-12 also provides approximate 95% confidence interval estimates for these population parameters. Figure 3-1 presents the cumulative distributions estimated for the population of portable and traditional classrooms.

Nearly all of the classrooms had indoor formaldehyde levels greater than typical outdoor levels in California (3 ppb), the Proposition 65 notification level equivalent for air (1.3 ppb), and the OEHHA Chronic Reference Exposure Level (REL) of 2.4 ppb for long-term exposure (ARB, 2001; OEHHA, 2002; OEHHA, 2001). The latter level is based on nasal and eye irritation and nasal/upper airway injury.

The short-term health-based guidelines for formaldehyde in California are 27 ppb (Draft 8-hour Indoor REL) and 76 ppb (1-hour level Acute REL) (Broadwin 2000; OEHHA, 1999). These guidelines are designed to protect against eye irritation and effects on the respiratory and immune systems. The 10-day average levels of formaldehyde are designed as screening estimates, and do not directly compare to standards and guidelines based on shorter time periods. However, because they are longer-term averages, they are probably conservative estimates of 1- and 8-hour levels of formaldehyde reached in classrooms.

The median 10-day H_2CO level for the overall classroom population was 22.0 ppb, but 10% of the classrooms were estimated to have levels above 50.3 ppb. The overall mean level was 27.0 ppb.

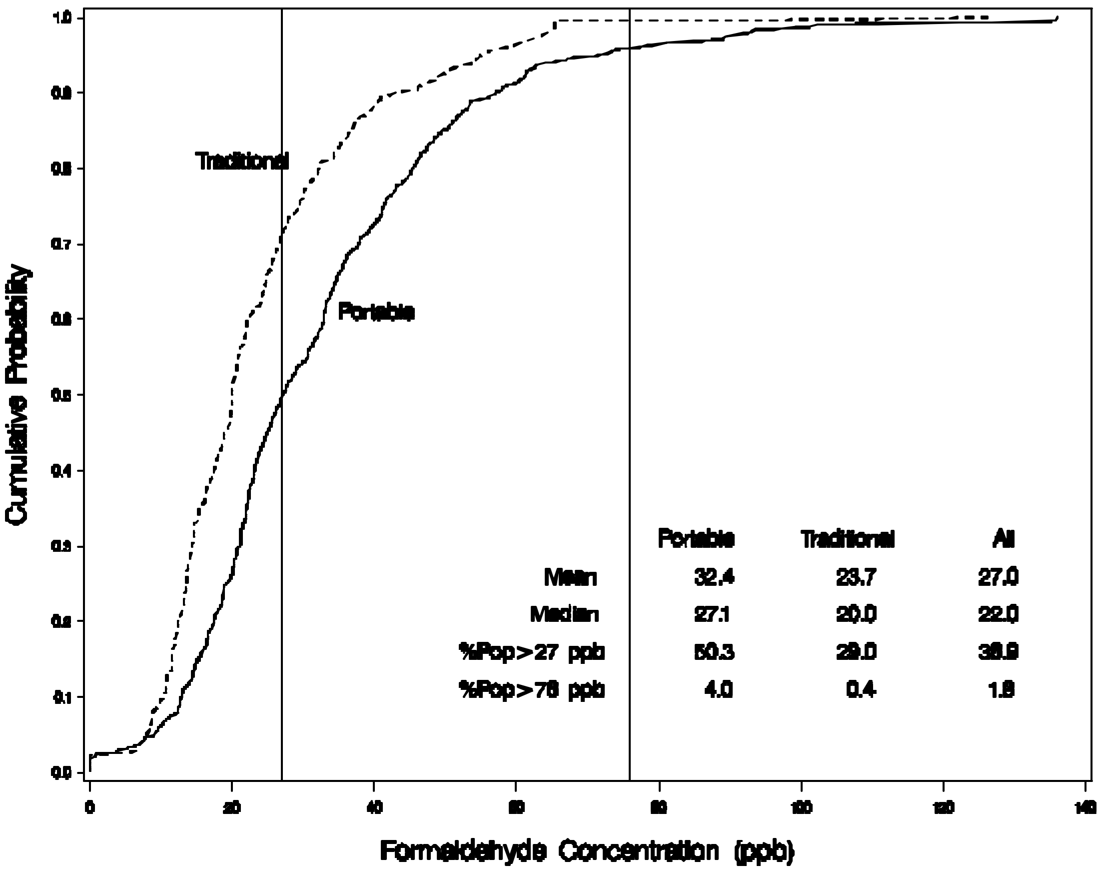
The results in Table 3-12 show a significant difference in the distribution of formaldehyde levels for portable classrooms, as compared to traditional classrooms. The levels in portable classrooms tend to be higher (numbers in parentheses are 95% confidence intervals) as evidenced by:

- a mean level of 32.4 ppb (30.0, 34.8) for portable classrooms versus 23.7 ppb (21.3, 26.2) for traditional classrooms
- a geometric mean of 24.9 ppb (22.4, 27.8) for portable classrooms versus 18.4 (16.0, 21.3) for traditional classrooms
- a median of 27.1 ppb (24.9, 30.6) for portable classrooms versus 20.0 ppb (18.3, 21.7) for traditional classrooms
- 50.3% (45.1, 55.6) of portable classrooms were estimated to exceed the 27 ppb guideline level, as compared to 29% (21.8, 36.2) of the traditional classrooms
- 4.0% (2.1, 6.0) of portable classrooms were estimated to exceed the 76 ppb guideline level, as compared to 0.4% (0.0, 0.9) of the traditional classrooms.

Table 3-12. Summary of Formaldehyde Levels

Statistic	Estimate for All Clrooms	Approx. Lower 95% CL for All Clrooms	Approx. Upper 95% CL for All Clrooms	Estimate for Port Clrooms	Approx. Lower 95% CL for Port Clrooms	Approx. Upper 95% CL for Port Clrooms	Estimate for Trad Clrooms	Approx. Lower 95% CL for Trad Clrooms	Approx. Upper 95% CL for Trad Clrooms
No. Obs	911			644			267		
Est. Pop. Size	230156			85416			144740		
% Pop. > LOD	97.0	95.3	98.7	96.6	94.7	98.5	97.2	94.9	99.5
% Pop. > 27ppb	36.9	31.3	42.5	50.3	45.1	55.6	29.0	21.8	36.2
% Pop. > 76ppb	1.8	0.9	2.6	4.0	2.1	6.0	0.4	0.0	0.9
Pop. Mean	27.0	24.9	29.0	32.4	30.0	34.8	23.7	21.3	26.2
Pop. Geom. Mean	20.6	18.5	23.1	24.9	22.4	27.8	18.4	16.0	21.3
5th Percentile	8.1	3.5	9.8	9.1	4.6	11.5	8.1	2.0	10.3
10th Percentile	10.8	9.1	12.3	12.9	10.7	14.8	10.4	8.9	11.9
25th Percentile	14.6	13.5	16.8	19.2	17.8	21.0	13.6	12.3	15.3
50th Percentile	22.0	20.7	24.3	27.1	24.9	30.6	20.0	18.3	21.7
75th Percentile	34.3	31.0	37.8	41.3	37.9	45.0	29.3	25.9	33.5
90th Percentile	50.3	44.7	57.3	57.1	51.5	63.2	42.8	36.1	53.6
95th Percentile	61.7	54.5	86.3	71.5	62.5	91.5	55.0	43.8	72.7

Figure 3-1. Cumulative Distributions of Formaldehyde Levels (~10-Day Passive Monitors) in Portable and Traditional Classrooms



Vertical lines are shown at 27 ppb, the draft 8-hour IREL, and at 76 ppb, the OEHHA Acute REL.

3.4.2 Comparison of Formaldehyde Levels in Portable and Traditional Classrooms

To compare portable and traditional classrooms' formaldehyde levels, formal hypothesis tests for differences in H_2CO levels were made, as indicated in Section 2.10, for the following:

- Difference in mean of log-scaled concentrations
- Difference in the percentage of rooms with levels exceeding 27 ppb
- Difference in the percentage of rooms with levels exceeding 76 ppb.

These comparisons were made over all classrooms and for designated subsets of classrooms. Detailed test results appear in Appendix F. Table 3-15 summarizes the test results by providing the p-values of the tests (last three columns). The Wald chi-square test results shown in the table will be discussed further in Section 3.4.3. Note that some of the categories have small sample sizes.

Based on the overall sample of 911 classrooms for which valid formaldehyde data were available, the estimates and estimated differences are shown in Table 3-13.

Table 3-13. Estimated Differences Between Portable and Traditional Classroom Formaldehyde Levels

Estimated H_2CO Statistic	Portable Classrooms	Traditional Classrooms	Difference	p-Value for t Test
Population mean of log-scaled concentrations	3.215	2.912	0.302	<0.001
Population percentage of rooms with levels > 27 ppb	50.3	29.0	21.4	<0.001
Population percentage of rooms with levels > 76 ppb	4.0	0.4	3.6	<0.001

Thus the two types of classrooms appear to be quite different ($p < 0.001$) in terms of geometric means and the percentages exceeding both the 27 and 76 ppb guidelines.

The overall population of classrooms was partitioned to form various subgroups and t tests were used to compare the two types of classrooms within each such subgroup. Table 3-15 summarizes the results. Due to the large *overall* differences in formaldehyde levels between portable and traditional classrooms, examination of Table 3-15 shows that most of the subgroups also show statistically significant differences between portable and traditional classrooms.

Some of the more important subgroups of Table 3-15 for which statistically significant differences were *not* found ($p > 0.05$) are shown in Table 3-14 (includes only cases where the total sample size [across both types of rooms] was 100 or more).

Table 3-14. Important Subgroup with No Significant Difference Between Portable and Traditional Classrooms Over 27 ppb

Variable Description	Category	Total n	Portable vs. Traditional Diff in % >27ppb
Time of formaldehyde sample	June/July	195	6.5
TQ ITEMS:			
Permanent marker pen used	No	154	15.5
Whiteboard marker used	No	131	17.9
Epoxy/rubber cement used	Yes	126	13.1
Carpentry activity this year	Yes	263	10.0
In-room construction this year	Yes	117	3.7
Overall air quality (teacher)	Adequate Poor	277 100	11.3 22.3
Nose symptoms at home	Improves	166	10.5
Throat symptoms past 2 weeks	Occasional Frequent	250 129	12.8 15.7
Throat symptoms at home	Improves	167	8.9
Eye symptoms past 2 weeks	Frequent	121	15.8
Eye symptoms at home	Improves	139	-4.1
FQ ITEMS:			
Classroom age	11-20 years	123	-1.5
Classroom age	16+ years	201	-0.1
Major renovations/additions	Yes	233	9.1
HVAC or lighting renovations	Yes	167	0.1
New flooring past year	Don’t know	144	15.6

Table 3-15. Summary of Formaldehyde Tests#

Description	p-Value Wald Chi^2 Portable Clrooms	p-Value Wald Chi^2 All Clrooms	Category	p-values for t tests (Portable vs. Traditional)		
				log-scale mean	prop. >27 ppb	prop. >76 ppb
All classrooms	N	N	All	0.00	0.00	0.00
School location	0.68	0.49	Urban	0.07	0.01	0.19
			Suburb	0.00	0.00	0.00
			Rural	0.00	0.02	0.20
Geographic region	0.09	0.00	North	0.00	0.00	0.02
			South	0.01	0.00	0.00
School type	0.19	0.20	Elem	0.00	0.00	0.01
			Middle	0.36	0.00	0.09
			High	0.02	0.10	0.03
Month of formaldehyde sample	0.00	0.00	April	0.04	0.00	N
			May	0.00	0.00	0.00
			June/July	0.30	0.41	0.05
Time of formaldehyde sample	0.00	0.00	Early_April	0.93	0.06	N
			Late_April	0.03	0.00	N
			Early_May	0.10	0.12	0.04
			Late_May	0.01	0.00	0.01
			June/July	0.34	0.46	0.05
<25% non-weekday in samp period	0.19	0.25	Yes	0.01	0.00	0.02
			No	0.01	0.00	0.00
General instruction classroom	0.46	0.79	Yes	0.00	0.00	0.00
			No	0.04	0.08	0.16
Carpeted classroom	0.45	0.88	Full	0.01	0.00	0.00
			Partial	0.06	0.00	0.09
			None	0.02	0.07	0.20
Vinyl/linoleum floor	0.20	0.29	Yes	0.01	0.00	0.04
			No	0.02	0.02	0.00
Vinyl tackable wallboard	0.77	0.00	Yes	0.27	0.06	0.00
			No	0.00	0.00	0.07
Open windows	0.67	0.21	Never	0.13	0.02	0.06
			Infrequent	0.04	0.01	0.00
			Frequent	0.00	0.02	0.08
Open door to outside	0.16	0.07	Infreq	0.00	0.02	0.00
			Freq	0.78	0.01	0.04
			NA	0.00	0.00	0.03
Pressed wood furniture	0.15	0.65	Yes	0.00	0.00	0.00
			No	0.01	0.04	0.06

Description	p-Value Wald Chi^2 Portable Clrooms	p-Value Wald Chi^2 All Clrooms	Category	p-values for t tests (Portable vs. Traditional)		
				log-scale mean	prop. >27 ppb	prop. >76 ppb
Pressed wood table/desks	0.25	0.80	Yes	0.00	0.00	0.00
			No	0.02	0.01	0.02
Pressed wood bookcases	0.39	0.35	Yes	0.01	0.00	0.00
			No	0.02	0.00	0.00
Pressed wood cabinets	0.04	0.75	Yes	0.00	0.00	0.01
			No	0.03	0.03	0.00
New furnishings this school yr	0.28	0.48	Yes	0.00	0.00	0.07
			No	0.03	0.00	0.00
			DK	0.00	0.15	0.32
Type appliances in room	0.10	0.56	Stove/burnr	0.55	0.24	0.28
			Other	0.78	0.02	0.04
			None	0.00	0.00	0.00
Chemical present in room	0.04	0.59	Yes	0.00	0.00	0.00
			No	0.03	0.02	0.02
Oil/acrylic paints used	0.43	0.09	Yes	0.28	0.00	0.01
			No	0.00	0.00	0.01
Permanent marker/pen used	0.77	0.45	Yes	0.00	0.00	0.00
			No	0.11	0.13	0.06
Whiteboard marker used	0.48	0.53	Yes	0.00	0.00	0.00
			No	0.32	0.09	0.19
Glues/fluids used	0.56	0.51	Yes	0.00	0.00	0.00
			No	0.02	0.00	0.02
Correction fluid used	0.84	0.50	Yes	0.00	0.00	0.00
			No	0.03	0.00	0.01
Epoxy/rubber cement used	0.27	0.87	Yes	0.64	0.25	0.11
			No	0.00	0.00	0.00
Air freshener used	0.34	0.12	Yes	0.74	0.02	0.01
			No	0.00	0.00	0.00
Air freshener used - plug-in	0.55	0.66	Yes	0.96	0.17	0.05
			No	0.00	0.00	0.00
Air freshener used - spray	0.31	0.19	Yes	0.80	0.09	0.06
			No	0.00	0.00	0.00
New furnishings odor	0.08	0.03	Never	0.00	0.00	0.00
			Sometimes	0.01	0.00	0.05
			Often	0.77	0.03	N

Description	p-Value Wald Chi^2 Portable Clrooms	p-Value Wald Chi^2 All Clrooms	Category	p-values for t tests (Portable vs. Traditional)		
				log-scale mean	prop. >27 ppb	prop. >76 ppb
Construction activity this yr	0.58	0.06	Current	0.10	0.20	0.04
			Previous	0.01	0.01	0.00
			Never	0.00	0.00	0.03
			Unknown	0.38	0.00	N
Carpentry activity this yr	0.52	0.36	Yes	0.06	0.24	0.08
			No	0.00	0.00	0.00
In-room construction this yr	0.45	0.38	Yes	0.83	0.76	0.19
			No	0.00	0.00	0.00
Other school construction this yr	0.87	0.01	Yes	0.00	0.01	0.00
			No	0.07	0.00	0.01
# teacher complaints in school yr	0.54	0.96	0	0.10	0.02	0.00
			1-5	0.00	0.00	0.01
			>5	0.20	0.31	0.47
Overall air quality (teacher)	0.97	0.45	Excellent	0.00	0.02	0.08
			Good	0.00	0.00	0.01
			Adequate	0.84	0.16	0.07
			Poor	0.26	0.06	0.13
			Very_poor	0.74	0.39	N
Nose symptoms past 2 weeks	0.77	0.42	None	0.02	0.00	0.01
			Occasional	0.02	0.01	0.02
			Frequent	0.37	0.05	0.45
Nose symptoms at home	0.29	0.57	Same/worse	0.01	0.00	0.01
			Improves	0.89	0.34	0.64
			NA	0.02	0.00	0.01
Throat symptoms past 2 weeks	0.87	0.48	None	0.00	0.00	0.00
			Occasional	0.25	0.12	0.06
			Frequent	0.42	0.15	0.13
Throat symptoms at home	0.87	0.50	Same/worse	0.02	0.13	0.08
			Improves	0.39	0.46	0.21
			NA	0.00	0.00	0.00
Eyes symptoms past 2 weeks	0.32	0.56	None	0.01	0.00	0.00
			Occasional	0.01	0.02	0.14
			Frequent	0.82	0.10	0.08
Eyes symptoms at home	0.36	0.28	Same/worse	0.00	0.00	0.58
			Improves	0.50	0.75	0.07
			NA	0.01	0.00	0.00

Description	p-Value Wald Chi^2 Portable Clrooms	p-Value Wald Chi^2 All Clrooms	Category	p-values for t tests (Portable vs. Traditional)		
				log-scale mean	prop. >27 ppb	prop. >76 ppb
Classroom age (yrs)	0.01	0.00	<=10yr	0.00	0.00	0.01
			11-20yr	0.65	0.94	0.09
			21-30yr	0.47	0.24	0.17
			31-40yr	0.65	0.27	N
			41+yr	0.02	0.23	0.32
Classroom age (yrs)	0.00	0.00	0-3yr	0.00	0.00	0.06
			4-5yr	0.93	0.04	0.07
			6-10yr	0.87	0.00	0.31
			11-15yr	0.67	0.91	0.08
			16+yr	0.16	0.99	0.20
Classroom age (known/unknown)	0.95	0.29	Known	0.01	0.00	0.00
			Unknown	0.00	0.00	0.08
Major renovations/additions	0.13	0.68	Yes	0.14	0.21	0.56
			No	0.00	0.00	0.00
Addition/wall/floor renovations	0.72	0.69	Yes	0.03	0.03	0.32
			No	0.00	0.00	0.00
HVAC or lighting renovations	0.06	0.96	Yes	0.38	0.99	0.32
			No	0.00	0.00	0.00
Roof renovations	0.37	0.55	Yes	0.32	0.34	0.33
			No	0.00	0.00	0.00
Classroom size (sq. ft.)	0.04	0.18	<600	0.85	0.00	0.12
			600-1100	0.06	0.02	0.01
			>1100	0.00	0.00	0.02
Outdoor damper min setting	0.21	0.42	<=10%	0.31	0.40	0.34
			11-20%	0.00	0.06	0.12
			21-40%	0.21	0.17	N
			>40%	0.32	0.99	0.09
			Unknown	0.03	0.00	0.00
New pressed wood last yr	0.09	0.05	Yes	0.05	0.01	0.03
			No	0.00	0.00	0.01
			DK	0.47	0.77	0.11
New carpet past yr	0.18	0.19	Yes	0.03	0.03	0.05
			No	0.00	0.00	0.00

Description	p-Value Wald Chi^2 Portable Clrooms	p-Value Wald Chi^2 All Clrooms	Category	p-values for t tests (Portable vs. Traditional)		
				log-scale mean	prop. >27 ppb	prop. >76 ppb
New flooring past yr	0.17	0.41	Yes	0.00	0.03	0.03
			No	0.00	0.00	0.00
			DK	0.76	0.11	0.16

[#] Detailed results associated with the Wald Chi-square tests are given in Table 3-14 and Appendix G. Detailed results associated with the t tests are given in Appendix F. The latter tests compare portables and traditionals and apply to *each* category, while the Chi-square tests provide an indication of whether different formaldehyde levels occur for the different categories (e.g., for urban, suburban, and rural schools).

Classroom age appears as one of the categories with the most distinct effect. For the newer classrooms (10 years old or less) even larger differences in formaldehyde levels occur, as compared to the general population of classrooms, as shown in Table 3-16.

Table 3-16. Estimated Formaldehyde Differences for Portable and Traditional Classrooms That are 10 Years Old or Less

Estimated H_2CO Statistic For Classrooms = 10 yrs	**Portable Classrooms**	**Traditional Classrooms**	**Difference**	**p-Value for t Test**
Number of Observations	250	23		
Subpopulation mean of log-scaled concentrations	3.2672	2.7852	0.4820	<0.001
Subpopulation percentage of rooms with levels > 27 ppb	57.3	12.8	44.5	<0.001
Subpopulation percentage of rooms with levels > 76 ppb	4.0	0.2	3.8	<0.001

3.4.3 Examination of Factors Associated with Increased Formaldehyde Levels

Factors affecting formaldehyde levels were examined in two ways: using Wald Chi-square tests and using ANOVA tests. These are addressed below.

Wald Chi-Square Tests. Table 3-17 provides statistics that allow an examination of whether a given factor (e.g., school type) is associated with the percentage of classrooms with formaldehyde levels exceeding 27 ppb. The objective of this table is to characterize classrooms with respect to formaldehyde levels, rather than to compare the two types of classrooms (which is done via ANOVA tests). Hence, statistics are shown for both portable classrooms and all classrooms. These statistics are:

- for each factor: the value of the p-value associated with a Wald chi-square statistic that tests if the percentage of the population exceeding 27 ppb differs from level to level of the factor. (Null hypothesis for a 3-level factor, for instance, is that $P_1=P_2=P_3$ where P_j = percent of eligible classrooms with H_2CO levels > 27 ppb. The p values shown are the same as those given in Table 3-13.)
- for each level (j) of each factor:
  - n_j = number of sample classrooms in category j
  - estimate $\left(\hat{P}_j\right)$ of the population percentage with levels above 27 ppb
  - estimate $\left(100 - \hat{P}_j\right)$ of the population percentage with levels less than or equal to 27 ppb.

Appendix G provides confidence interval estimates for the P_j, in addition to the statistics given in Table 3-17.

For portable classrooms, the factors showing significant differences ($p < 0.05$) in H_2CO levels were the following (see Table 2-5 for variable definitions):

- month of formaldehyde sample (highest H_2CO level in June/July; lowest in April)
- presence of pressed wood cabinets (higher levels when present)
- presence of chemicals (higher levels when present)
- classroom age (higher levels for newer rooms [≤ 5 years old])
- classroom size (higher levels for large rooms [> 1,100 sq. ft.].

Table 3-17. Classification of Classrooms, by Formaldehyde Level and Other Selected Variables

Classification Variable	Category	Portable Classrooms p-Value Wald Chi^2	n	Est. Pop. Percent <=27ppb	Est. Pop. Percent >27ppb	All Classrooms p-Value Wald Chi^2	n	Est. Pop. Percent <=27ppb	Est. Pop. Percent >27ppb
All classrooms	All		644	49.7	50.3		911	63.1	36.9
School location	Urban	0.68	102	48.2	51.8	0.49	147	62.9	37.1
	Suburb		487	49.2	50.8		684	62.2	37.8
	Rural		55	57.8	42.2		80	72.8	27.2
Geographic region	North	0.09	283	55.4	44.6	0.00	397	74.1	25.9
	South		361	46.1	53.9		514	56.4	43.6
School type	Elem	0.19	419	45.8	54.2	0.20	592	58.3	41.7
	Middle		103	52.1	47.9		149	68.6	31.4
	High		122	57.7	42.3		170	68.0	32.0
Month of formaldehyde sample	April	0.00	165	69.2	30.8	0.00	241	86.1	13.9
	May		335	46.0	54.0		471	59.7	40.3
	June/July		144	32.6	67.4		199	37.0	63.0
Time of formaldehyde sample	Early_April	0.00	43	90.6	9.4	0.00	64	96.5	3.5
	Late_April		122	63.7	36.3		177	83.4	16.6
	Early_May		154	44.9	55.1		219	52.6	47.4
	Late_May		181	46.9	53.1		252	65.5	34.5
	June/July		141	32.5	67.5		195	36.4	63.6
<25% non-weekday in samp period	Yes	0.19	332	52.9	47.1	0.25	475	65.9	34.1
	No		309	45.9	54.1		432	59.5	40.5
General instruction classroom	Yes	0.46	529	51.6	48.4	0.79	744	64.7	35.3
	No		64	45.1	54.9		93	62.2	37.8
Carpeted classroom	Full	0.45	433	53.2	46.8	0.88	528	62.5	37.5
	Partial		128	45.7	54.3		221	64.0	36.0
	None		37	45.1	54.9		95	66.0	34.0
Vinyl/linoleum floor	Yes	0.20	171	45.6	54.4	0.29	305	66.7	33.3
	No		427	53.3	46.7		539	61.2	38.8
Vinyl tackable wallboard	Yes	0.77	464	50.3	49.7	0.00	541	56.0	44.0
	No		128	52.1	47.9		292	71.5	28.5
Open windows	Never	0.67	63	50.6	49.4	0.21	145	69.0	31.0
	Infrequent		349	49.3	50.7		447	58.5	41.5
	Frequent		179	54.5	45.5		238	66.4	33.6
Open door to outside	Infreq	0.16	308	52.6	47.4	0.07	427	61.1	38.9
	Freq		268	48.7	51.3		356	60.3	39.7
	NA		3	0.0	100.0		36	83.4	16.6

Classification Variable	Category	Portable Classrooms p-Value Wald Chi^2	Portable Classrooms n	Portable Classrooms Est. Pop. Percent <=27ppb	Portable Classrooms Est. Pop. Percent >27ppb	All Classrooms p-Value Wald Chi^2	All Classrooms n	All Classrooms Est. Pop. Percent <=27ppb	All Classrooms Est. Pop. Percent >27ppb
Pressed wood furniture	Yes	0.15	548	52.0	48.0	0.65	769	64.3	35.7
	No		50	39.3	60.7		75	60.2	39.8
Pressed wood table/desks	Yes	0.25	489	52.1	47.9	0.80	681	64.2	35.8
	No		109	44.9	55.1		163	62.5	37.5
Pressed wood bookcases	Yes	0.39	353	48.9	51.1	0.35	492	61.4	38.6
	No		245	53.8	46.2		352	66.6	33.4
Pressed wood cabinets	Yes	0.04	296	45.0	55.0	0.75	403	62.9	37.1
	No		302	56.5	43.5		441	64.6	35.4
New furnishings this school yr	Yes	0.28	162	44.4	55.6	0.48	214	61.5	38.5
	No		406	52.8	47.2		591	64.1	35.9
	DK		22	58.5	41.5		28	75.8	24.2
Type appliances in room	Stove/burnr	0.10	19	30.3	69.7	0.56	27	47.7	52.3
	Other		194	53.5	46.5		254	64.8	35.2
	None		329	52.6	47.4		475	65.2	34.8
Chemical present in room	Yes	0.04	285	45.0	55.0	0.59	407	62.4	37.6
	No		313	56.0	44.0		437	65.1	34.9
Oil/acrylic paints used	Yes	0.43	86	45.7	54.3	0.09	119	73.9	26.1
	No		512	51.6	48.4		725	62.4	37.6
Permanent marker/pen used	Yes	0.77	493	51.4	48.6	0.45	690	65.1	34.9
	No		105	49.2	50.8		154	59.6	40.4
Whiteboard marker used	Yes	0.48	507	50.0	50.0	0.53	713	63.0	37.0
	No		91	55.7	44.3		131	67.6	32.4
Glues/fluids used	Yes	0.56	410	51.9	48.1	0.51	570	65.1	34.9
	No		188	48.8	51.2		274	61.3	38.7
Correction fluid used	Yes	0.84	378	51.3	48.7	0.50	526	65.3	34.7
	No		220	50.3	49.7		318	61.5	38.5
Epoxy/rubber cement used	Yes	0.27	93	57.4	42.6	0.87	126	64.8	35.2
	No		505	49.8	50.2		718	63.7	36.3
Air freshener used	Yes	0.34	238	47.7	52.3	0.12	311	57.7	42.3
	No		360	53.0	47.0		533	66.8	33.2
Air freshener used - plug-in	Yes	0.55	123	53.8	46.2	0.66	161	61.4	38.6
	No		475	50.2	49.8		683	64.3	35.7
Air freshener used - spray	Yes	0.31	132	45.4	54.6	0.19	172	56.8	43.2
	No		466	52.5	47.5		672	65.6	34.4

Classification Variable	Category	Portable Classrooms p-Value Wald Chi^2	n	Est. Pop. Percent <=27ppb	Est. Pop. Percent >27ppb	All Classrooms p-Value Wald Chi^2	n	Est. Pop. Percent <=27ppb	Est. Pop. Percent >27ppb
New furnishings odor	Never	0.08	481	53.7	46.3	0.03	699	65.0	35.0
	Sometimes		78	40.9	59.1		102	58.3	41.7
	Often		16	26.9	73.1		17	23.1	76.9
Construction activity this yr	Current	0.58	136	44.9	55.1	0.06	186	53.0	47.0
	Previous		287	53.6	46.4		404	64.0	36.0
	Never		155	50.6	49.4		227	71.2	28.8
	Unknown		13	56.8	43.2		16	80.8	19.2
Carpentry activity this yr	Yes	0.52	185	53.5	46.5	0.36	263	60.0	40.0
	No		413	49.7	50.3		581	65.7	34.3
In-room construction this yr	Yes	0.45	77	55.4	44.6	0.38	117	57.9	42.1
	No		516	50.0	50.0		721	64.8	35.2
Other school construction this yr	Yes	0.87	409	50.6	49.4	0.01	568	59.6	40.4
	No		189	51.7	48.3		276	73.0	27.0
# teacher complaints in school yr	0	0.54	232	54.0	46.0	0.96	335	63.3	36.7
	1-5		308	48.3	51.7		430	63.6	36.4
	>5		47	54.6	45.4		62	66.5	33.5
Overall air quality (teacher)	Excellent	0.97	87	49.3	50.7	0.45	132	63.3	36.7
	Good		206	51.8	48.2		307	69.5	30.5
	Adequate		204	49.5	50.5		277	56.4	43.6
	Poor		78	51.9	48.1		100	65.0	35.0
	Very_poor		14	58.4	41.6		17	70.2	29.8
Nose symptoms past 2 weeks	None	0.77	239	52.8	47.2	0.42	342	67.5	32.5
	Occasional		194	49.7	50.3		291	61.6	38.4
	Frequent		150	48.2	51.8		194	59.3	40.7
Nose symptoms at home	Same/worse	0.29	179	45.5	54.5	0.57	264	62.3	37.7
	Improves		129	55.3	44.7		166	61.0	39.0
	NA		239	52.8	47.2		342	67.5	32.5
Throat symptoms past 2 weeks	None	0.87	302	50.1	49.9	0.48	436	67.0	33.0
	Occasional		175	51.4	48.6		250	59.5	40.5
	Frequent		99	54.2	45.8		129	62.2	37.8
Throat symptoms at home	Same/worse	0.87	117	52.8	47.2	0.50	167	62.0	38.0
	Improves		128	53.8	46.2		167	58.6	41.4
	NA		302	50.1	49.9		436	67.0	33.0
Eyes symptoms past 2 weeks	None	0.32	320	50.8	49.2	0.56	458	64.9	35.1
	Occasional		152	45.6	54.4		224	59.2	40.8
	Frequent		91	59.5	40.5		121	68.1	31.9

Classification Variable	Category	Portable Classrooms				All Classrooms			
		p-Value Wald Chi^2	n	Est. Pop. Percent <=27ppb	Est. Pop. Percent >27ppb	p-Value Wald Chi^2	n	Est. Pop. Percent <=27ppb	Est. Pop. Percent >27ppb
Eyes symptoms at home	Same/worse	0.36	101	44.3	55.7	0.28	158	68.8	31.2
	Improves		108	56.3	43.7		139	54.2	45.8
	NA		320	50.8	49.2		458	64.9	35.1
Classroom age (yrs)	<=10yr	0.01	250	42.7	57.3	0.00	273	54.5	45.5
	11-20yr		110	51.7	48.3		123	51.3	48.7
	21-30yr		28	84.9	15.1		50	92.8	7.2
	31-40yr		20	72.2	27.8		50	55.5	44.5
	41+yr		4	34.0	66.0		69	66.1	33.9
	0-3yr	0.00	113	34.3	65.7	0.00	119	48.3	51.7
	4-5yr		73	40.1	59.9		77	36.4	63.6
	6-10yr		64	60.9	39.1		77	76.8	23.2
	11-15yr		82	50.4	49.6		91	51.2	48.8
	16+yr		80	70.4	29.6		201	70.3	29.7
Classroom age (known/unknown)	Known	0.95	412	50.7	49.3	0.29	565	63.1	36.9
	Unknown		162	51.1	48.9		245	69.2	30.8
Major renovations/additions	Yes	0.13	124	59.9	40.1	0.68	233	66.8	33.2
	No		421	49.5	50.5		535	64.4	35.6
Addition/wall/floor renovations	Yes	0.72	42	49.7	50.3	0.69	87	68.0	32.0
	No		503	52.3	47.7		681	64.9	35.1
HVAC or lighting renovations	Yes	0.06	79	65.0	35.0	0.96	167	65.1	34.9
	No		466	49.5	50.5		601	65.5	34.5
Roof renovations	Yes	0.37	36	60.3	39.7	0.55	92	69.1	30.9
	No		509	51.3	48.7		676	64.4	35.6
Classroom size (sq. ft.)	<600	0.04	44	52.0	48.0	0.18	66	76.2	23.8
	600-1100		401	54.6	45.4		538	61.4	38.6
	>1100		129	39.3	60.7		206	68.7	31.3
Outdoor damper min setting	<=10%	0.21	36	65.2	34.8	0.42	48	71.3	28.7
	11-20%		80	58.2	41.8		122	70.4	29.6
	21-40%		16	74.1	25.9		22	87.8	12.2
	>40%		16	43.4	56.6		22	43.3	56.7
	Unknown		351	49.8	50.2		484	64.8	35.2
New pressed wood last yr	Yes	0.09	167	42.9	57.1	0.05	228	54.7	45.3
	No		303	56.0	44.0		429	71.6	28.4
	DK		57	56.8	43.2		81	59.5	40.5
New carpet past yr	Yes	0.18	108	44.2	55.8	0.19	138	57.5	42.5
	No		437	53.9	46.1		630	66.6	33.4

Classification Variable	Category	Portable Classrooms				All Classrooms			
		p-Value Wald Chi^2	n	Est. Pop. Percent <=27ppb	Est. Pop. Percent >27ppb	p-Value Wald Chi^2	n	Est. Pop. Percent <=27ppb	Est. Pop. Percent >27ppb
New flooring past yr	Yes	0.17	135	46.2	53.8	0.41	183	59.3	40.7
	No		303	50.9	49.1		441	65.6	34.4
	DK		107	61.9	38.1		144	71.2	28.8

The classroom size effect may indicate that different types of activities or ventilation occur in the larger rooms. A number of other factors are marginally significant for portables (e.g., new furnishings odor, new pressed wood last year), perhaps due to small sample sizes.

For all classrooms, the significant factors (see Table 2-5 for variable definitions) were:

- geographic region (higher H_2CO levels in the South)
- month of formaldehyde sample (highest H_2CO level in June/July; lowest in April)
- presence of vinyl tackable wallboard (higher levels when present)
- classroom age (higher levels for newer rooms)
- new pressed wood last year (higher levels when present)
- new furnishings odor (higher levels when present)
- other school construction (higher levels when present).

It should be noted that several variables were significant (or marginally so) for portables but not for all classrooms—e.g., pressed wood cabinets, chemicals present in room, new furnishings odor, HVAC or lighting renovations, and classroom size. Several potentially important variables were not found to be statistically significant in either portable or all classrooms: teacher complaints, teacher symptoms (eye, nose, and throat), outdoor air minimum setting, new carpet, and new flooring.

ANOVA Tests. An alternative to the Wald chi-square tests described above, which examined the homogeneity of the percentages above 27 ppb, is the analysis of variance approach. As described in Section 2.10, these analyses provide weighted ANOVA tests for the log-scale formaldehyde concentrations, using both an interaction and a main effects model. Illustrative output from the SUDAAN REGRESS procedure is shown in Exhibits 3-1 and 3-2. The first of these shows results for the models involving the ROOMTYPE and POPSTAT (urban, suburban, rural) variables; the second shows outputs for the ROOMTYPE and CLRAGE (classroom age) variables. Each of the exhibits presents the results of two models: the first part of the output shows the test of the interaction between ROOMTYPE (i.e., portable vs. traditional) and the given variable X (e.g., classroom age). The second part, which is only appropriate if the interaction effect can be ignored, shows the tests of the main effects of the two variables appearing in the model.

Table 3-18 summarizes the results of the ANOVA tests by providing the p-values associated with the adjusted Wald F tests for selected factors, for room type (portable vs. traditional), and for the interaction of these two factors. Also shown are the relevant population-weighted cell counts, log-scale means, and associated geometric means (in ppb). Based on the results in this table, the following factors appeared to interact with room type (p = 0.05):

- Open door to outside: There is little difference in formaldehyde levels between portable and traditional classrooms for rooms with exterior doors frequently open; otherwise, portables tend to have higher levels.
- Air freshener used: Portable classrooms tend to have higher formaldehyde levels than traditional classrooms in rooms where air fresheners are not used but comparable levels when air fresheners are used.
- New furnishing odor: Higher formaldehyde levels are observed for rooms in which new furnishing odors are present; this effect is more pronounced for the portables than for the traditional classrooms.
- Throat symptoms at home: A different pattern is observed for portable and traditional classrooms; sample sizes for the traditional classrooms are small.
- Classroom age (2nd version): Portable classrooms tend to have higher formaldehyde levels than traditional classrooms in the newest age group (0 to 3 years); for the other age groups, there is not much difference between the two types of rooms.
- Classroom size: A larger difference in formaldehyde levels between portable classrooms and traditional classrooms occurs for larger rooms (>1100 square feet).

Among the remaining factors, the following showed statistically significant main effects (p = 0.05) – that is, effects that were prevalent for both types of rooms:

- Geographic region: Higher formaldehyde levels occur in the southern region.
- Time of formaldehyde sample: Higher formaldehyde levels occur in the summer months.
- Overall air quality rating: There are differences between the levels of this variable, but there is not a logical pattern to them.
- Nose symptoms past 2 weeks: Higher formaldehyde levels are found in those rooms where teachers reported frequent nasal problems.
- New carpet: Higher formaldehyde levels are found in those rooms with new carpet in the past year.
- New flooring: Higher formaldehyde levels are found in those rooms with new flooring in the past year.

Among all the models, the room type variable, adjusted for the other variable appearing in the model, is always highly significant—with one exception. This exception occurs for the models involving classroom age (both versions of the variable, CLRAGE and CLRAGEX). For these models the effect of room type, after adjustment, is non-significant, suggesting that at least part of the overall differences between the room types is due to the disparity in their age distributions.

Exhibit 3-1. Analysis of Variance Models Involving Type of Room and Popstat

```
Number of observations read       :    911    Weighted count:   230156
Observations used in the analysis :    911    Weighted count:   230156
Denominator degrees of freedom    :    319
File _CCC contains  320 Clusters; 320 clusters were used to fit the model
Maximum cluster size = 3 records      Minimum cluster size = 1 records
Weighted mean response is 3.026986
```

INTERACTION MODEL RESULTS

Multiple R-Square for the dependent variable LNMEAS: 0.022718

Contrast	Degrees of Freedom	Wald F	P-value Wald F	Adj Wald F	P-value Adj Wald F
OVERALL MODEL	6	904.87	0.0000	890.69	0.0000
MODEL MINUS INTERCEPT	5	4.74	0.0003	4.68	0.0004
INTERCEPT	.	.	.	.	.
ROOMTYPE	.	.	.	.	.
POPSTAT	.	.	.	.	.
ROOMTYPE * POPSTAT	2	0.14	0.8658	0.14	0.8662

MAIN EFFECTS MODEL RESULTS

Multiple R-Square for the dependent variable LNMEAS: 0.022609

Contrast	Degrees of Freedom	Wald F	P-value Wald F	Adj Wald F	P-value Adj Wald F
OVERALL MODEL	4	1310.20	0.0000	1297.88	0.0000
MODEL MINUS INTERCEPT	3	5.71	0.0008	5.68	0.0008
INTERCEPT	.	.	.	.	.
ROOMTYPE	1	15.19	0.0001	15.19	0.0001
POPSTAT	2	0.19	0.8310	0.18	0.8315

Exhibit 3-2. Analysis of Variance Models Involving Type of Room and Classroom Age

```
Number of observations read       :    810    Weighted count:   230156
Number of observations skipped    :    101 (WEIGHT variable nonpositive)
Observations used in the analysis :    565    Weighted count:   153951
Denominator degrees of freedom    :    283
File _CCC contains  284 Clusters; 227 clusters were used to fit the model
Maximum cluster size = 3 records      Minimum cluster size = 1 records
Weighted mean response is 3.038277
```

INTERACTION MODEL RESULTS

Multiple R-Square for the dependent variable LNMEAS: 0.043837

Contrast	Degrees of Freedom	Wald F	P-value Wald F	Adj Wald F	P-value Adj Wald F
OVERALL MODEL	10	301.53	0.0000	291.94	0.0000
MODEL MINUS INTERCEPT	9	2.73	0.0046	2.65	0.0059
INTERCEPT	.	.	.	.	.
ROOMTYPE	.	.	.	.	.
CLRAGE	.	.	.	.	.
ROOMTYPE * CLRAGE	4	1.26	0.2854	1.25	0.2908

MAIN EFFECTS MODEL RESULTS

Multiple R-Square for the dependent variable LNMEAS: 0.034727

Contrast	Degrees of Freedom	Wald F	P-value Wald F	Adj Wald F	P-value Adj Wald F
OVERALL MODEL	6	413.84	0.0000	406.53	0.0000
MODEL MINUS INTERCEPT	5	3.00	0.0118	2.95	0.0129
INTERCEPT	.	.	.	.	.
ROOMTYPE	1	2.82	0.0940	2.82	0.0940
CLRAGE	4	0.97	0.4264	0.96	0.4321

Table 3-18. Summary of ANOVA Results for LN (Formaldehyde Conc)

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
OVERALL	All classrooms	NA	0.000	NA	All	All	911	230156	3.0270	20.6
					All	Port	644	85416	3.2167	24.9
					All	Trad	267	144740	2.9151	18.4
POPSTAT	School location	0.831	0.000	0.866	Urban	All	147	40824	3.0467	21.0
					Urban	Port	102	13035	3.2332	25.4
					Urban	Trad	45	27788	2.9593	19.3
					Suburb	All	684	173419	3.0259	20.6
					Suburb	Port	487	66262	3.2135	24.9
					Suburb	Trad	197	107157	2.9099	18.4
					Rural	All	80	15913	2.9881	19.8
					Rural	Port	55	6118	3.2153	24.9
					Rural	Trad	25	9795	2.8463	17.2
REGION	Geographic region	0.014	0.000	0.441	North	All	397	86702	2.8622	17.5
					North	Port	283	32659	3.0982	22.2
					North	Trad	114	54043	2.7196	15.2
					South	All	514	143454	3.1266	22.8
					South	Port	361	52757	3.2900	26.8
					South	Trad	153	90697	3.0315	20.7
SCHTYPE	School type	0.638	0.000	0.456	Elem	All	592	119045	3.0829	21.8
					Elem	Port	419	50580	3.2481	25.7
					Elem	Trad	173	68465	2.9609	19.3
					Middle	All	149	46772	3.0610	21.3
					Middle	Port	103	15540	3.1495	23.3
					Middle	Trad	46	31232	3.0169	20.4

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					High	All	170	64339	2.8988	18.2
					High	Port	122	19296	3.1883	24.2
					High	Trad	48	45043	2.7748	16.0
SAMPMO	Month of formaldehyde sample	0.000	0.000	0.239	April	All	241	70689	2.7071	15.0
					April	Port	165	24201	2.8845	17.9
					April	Trad	76	46488	2.6147	13.7
					May	All	471	111745	3.0706	21.6
					May	Port	335	42578	3.2983	27.1
					May	Trad	136	69167	2.9305	18.7
					June/July	All	199	47722	3.3987	29.9
					June/July	Port	144	18637	3.4615	31.9
					June/July	Trad	55	29085	3.3584	28.7
SAMPTIME	Time of formaldehyde sample	0.000	0.000	0.321	Early_April	All	64	14554	2.5209	12.4
					Early_April	Port	43	4966	2.5325	12.6
					Early_April	Trad	21	9589	2.5149	12.4
					Late_April	All	177	56135	2.7553	15.7
					Late_April	Port	122	19235	2.9754	19.6
					Late_April	Trad	55	36899	2.6406	14.0
					Early_May	All	219	50538	3.2113	24.8
					Early_May	Port	154	18970	3.3560	28.7
					Early_May	Trad	65	31569	3.1244	22.7
					Late_May	All	252	61207	2.9545	19.2
					Late_May	Port	181	23608	3.2519	25.8
					Late_May	Trad	71	37599	2.7677	15.9
					June/July	All	195	47116	3.4081	30.2

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					June/July	Port	141	18421	3.4670	32.0
					June/July	Trad	54	28695	3.3703	29.1
PWDXPOSC	<25% non-weekday in samp period	0.457	0.000	0.601	Yes	All	475	127884	2.9863	19.8
					Yes	Port	332	45716	3.1532	23.4
					Yes	Trad	143	82168	2.8933	18.1
					No	All	432	101666	3.0804	21.8
					No	Port	309	39484	3.2913	26.9
					No	Trad	123	62182	2.9464	19.0
GENINST	General instruction classroom	0.106	0.000	0.871	Yes	All	744	188161	2.9822	19.7
					Yes	Port	529	75614	3.1976	24.5
					Yes	Trad	215	112546	2.8376	17.1
					No	All	93	39852	3.1368	23.0
					No	Port	64	9080	3.3901	29.7
					No	Trad	29	30773	3.0620	21.4
CARPET	Carpeted classroom	0.237	0.000	0.926	Full	All	528	111611	2.9944	20.0
					Full	Port	433	59952	3.1795	24.0
					Full	Trad	95	51659	2.7797	16.1
					Partial	All	221	58271	2.9631	19.4
					Partial	Port	128	18174	3.1849	24.2
					Partial	Trad	93	40097	2.8626	17.5
					None	All	95	60274	3.0822	21.8
					None	Port	37	7290	3.4383	31.1
					None	Trad	58	52984	3.0332	20.8
VINYLFL	Vinyl/linoleum floor	0.458	0.001	0.987	Yes	All	305	109034	3.0134	20.4
					Yes	Port	171	26050	3.2673	26.2

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					Yes	Trad	134	82984	2.9337	18.8
					No	All	539	121122	3.0059	20.2
					No	Port	427	59366	3.1744	23.9
					No	Trad	112	61756	2.8440	17.2
VINYLWL	Vinyl tackable wallboard	0.418	0.010	0.158	Yes	All	541	109990	3.1187	22.6
					Yes	Port	464	66725	3.1825	24.1
					Yes	Trad	77	43265	3.0204	20.5
					No	All	292	116536	2.8990	18.2
					No	Port	128	17315	3.2774	26.5
					No	Trad	164	99221	2.8330	17.0
WINDOPEN	Open windows	0.972	0.000	0.930	Never	All	145	59295	2.9662	19.4
					Never	Port	63	10196	3.2006	24.5
					Never	Trad	82	49100	2.9175	18.5
					Infrequent	All	447	102420	3.0261	20.6
					Infrequent	Port	349	47645	3.1976	24.5
					Infrequent	Trad	98	54775	2.8769	17.8
					Frequent	All	238	61938	3.0263	20.6
					Frequent	Port	179	26269	3.2361	25.4
					Frequent	Trad	59	35669	2.8717	17.7
DOOROPEN	Open door to outside	0.185	0.003	0.001	Infreq	All	427	105524	3.0389	20.9
					Infreq	Port	308	45164	3.2527	25.9
					Infreq	Trad	119	60360	2.8789	17.8
					Freq	All	356	87860	3.1149	22.5
					Freq	Port	268	36926	3.1344	23.0
					Freq	Trad	88	50934	3.1007	22.2

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					NA	All	36	29830	2.5553	12.9
					NA	Port	3	66	4.2565	70.6
					NA	Trad	33	29764	2.5515	12.8
PRESWOOD	Pressed wood furniture	0.593	0.000	0.194	Yes	All	769	203508	3.0019	20.1
					Yes	Port	548	77934	3.1707	23.8
					Yes	Trad	221	125574	2.8972	18.1
					No	All	75	26648	3.0671	21.5
					No	Port	50	7482	3.5366	34.4
					No	Trad	25	19165	2.8838	17.9
PRESWOD1	Pressed wood table/desks	0.234	0.000	0.688	Yes	All	681	180549	2.9869	19.8
					Yes	Port	489	71065	3.1696	23.8
					Yes	Trad	192	109484	2.8683	17.6
					No	All	163	49607	3.0916	22.0
					No	Port	109	14351	3.3669	29.0
					No	Trad	54	35256	2.9796	19.7
PRESWOD2	Pressed wood bookcases	0.436	0.000	0.996	Yes	All	492	123865	3.0583	21.3
					Yes	Port	353	49635	3.2391	25.5
					Yes	Trad	139	74231	2.9373	18.9
					No	All	352	106291	2.9526	19.2
					No	Port	245	35781	3.1523	23.4
					No	Trad	107	70509	2.8513	17.3
PRESWOD3	Pressed wood cabinets	0.875	0.000	0.258	Yes	All	403	103903	3.0084	20.3
					Yes	Port	296	41483	3.2616	26.1
					Yes	Trad	107	62419	2.8401	17.1
					No	All	441	126253	3.0104	20.3

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					No	Port	302	43933	3.1471	23.3
					No	Trad	139	82321	2.9374	18.9
NEWFURN	New furnishings this school yr	0.636	0.000	0.152	Yes	All	214	49215	3.0353	20.8
					Yes	Port	162	21446	3.3089	27.4
					Yes	Trad	52	27769	2.8240	16.8
					No	All	591	169405	3.0007	20.1
					No	Port	406	59010	3.1512	23.4
					No	Trad	185	110394	2.9203	18.5
					DK	All	28	8564	2.9112	18.4
					DK	Port	22	3579	3.2710	26.3
					DK	Trad	6	4985	2.6529	14.2
APPLIAN	Type appliances in room	0.523	0.000	0.062	Stove/burnr	All	27	13483	3.2005	24.5
					Stove/burnr	Port	19	4829	3.3334	28.0
					Stove/burnr	Trad	8	8654	3.1263	22.8
					Other	All	254	65172	3.0706	21.6
					Other	Port	194	28596	3.0931	22.0
					Other	Trad	60	36576	3.0531	21.2
					None	All	475	125947	2.9486	19.1
					None	Port	329	45014	3.2604	26.1
					None	Trad	146	80933	2.7752	16.0
CHEMPRES	Chemical present in room	0.151	0.000	0.966	Yes	All	407	111686	3.0801	21.8
					Yes	Port	285	39052	3.2869	26.8
					Yes	Trad	122	72634	2.9688	19.5
					No	All	437	118470	2.9429	19.0
					No	Port	313	46364	3.1318	22.9

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					No	Trad	124	72106	2.8215	16.8
PAINTS	Oil/acrylic paints used	0.790	0.000	0.982	Yes	All	119	28768	2.9728	19.5
					Yes	Port	86	10240	3.1743	23.9
					Yes	Trad	33	18528	2.8614	17.5
					No	All	725	201387	3.0147	20.4
					No	Port	512	75176	3.2066	24.7
					No	Trad	213	126212	2.9004	18.2
PMARKER	Permanent marker/pen used	0.272	0.000	0.645	Yes	All	690	177758	3.0586	21.3
					Yes	Port	493	67984	3.2274	25.2
					Yes	Trad	197	109774	2.9541	19.2
					No	All	154	52398	2.8427	17.2
					No	Port	105	17432	3.1063	22.3
					No	Trad	49	34966	2.7113	15.0
WBMARKER	Whiteboard marker used	0.604	0.000	0.366	Yes	All	713	188179	3.0218	20.5
					Yes	Port	507	71394	3.2304	25.3
					Yes	Trad	206	116785	2.8943	18.1
					No	All	131	41977	2.9543	19.2
					No	Port	91	14022	3.0620	21.4
					No	Trad	40	27955	2.9003	18.2
GLUFLU	Glues/fluids used	0.159	0.000	0.349	Yes	All	570	152451	3.0769	21.7
					Yes	Port	410	57549	3.2278	25.2
					Yes	Trad	160	94902	2.9854	19.8
					No	All	274	77705	2.8772	17.8
					No	Port	188	27867	3.1509	23.4
					No	Trad	86	49838	2.7241	15.2

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
CORFLU	Correction fluid used	0.273	0.000	0.615	Yes	All	526	140218	3.0638	21.4
					Yes	Port	378	52388	3.2335	25.4
					Yes	Trad	148	87829	2.9625	19.3
					No	All	318	89938	2.9249	18.6
					No	Port	220	33027	3.1539	23.4
					No	Trad	98	56911	2.7919	16.3
GLUES	Epoxy/rubber cement used	0.105	0.000	0.124	Yes	All	126	29778	3.1566	23.5
					Yes	Port	93	12924	3.1955	24.4
					Yes	Trad	33	16854	3.1269	22.8
					No	All	718	200378	2.9876	19.8
					No	Port	505	72492	3.2040	24.6
					No	Trad	213	127886	2.8649	17.5
AFRESH	Air freshener used	0.353	0.000	0.015	Yes	All	311	74849	3.0852	21.9
					Yes	Port	238	33106	3.1060	22.3
					Yes	Trad	73	41743	3.0688	21.5
					No	All	533	155307	2.9730	19.5
					No	Port	360	52310	3.2640	26.2
					No	Trad	173	102997	2.8252	16.9
AFRESHP	Air freshener used - plug-in	0.466	0.000	0.039	Yes	All	161	36508	2.9778	19.6
					Yes	Port	123	17274	2.9735	19.6
					Yes	Trad	38	19234	2.9817	19.7
					No	All	683	193648	3.0154	20.4
					No	Port	475	68142	3.2608	26.1
					No	Trad	208	125506	2.8822	17.9
AFRESHS	Air freshener used - spray	0.253	0.000	0.107	Yes	All	172	45884	3.1126	22.5

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					Yes	Port	132	19393	3.1362	23.0
					Yes	Trad	40	26492	3.0952	22.1
					No	All	672	184271	2.9838	19.8
					No	Port	466	66023	3.2223	25.1
					No	Trad	206	118248	2.8507	17.3
NEWODOR	New furnishings odor	0.000	0.000	0.018	Never	All	699	203163	2.9910	19.9
					Never	Port	481	68750	3.1753	23.9
					Never	Trad	218	134412	2.8966	18.1
					Sometimes	All	102	19471	3.1520	23.4
					Sometimes	Port	78	10683	3.4060	30.1
					Sometimes	Trad	24	8788	2.8433	17.2
					Often	All	17	2488	3.6367	38.0
					Often	Port	16	2132	3.6316	37.8
					Often	Trad	1	356	3.6674	39.1
CONST	Construction activity this yr	0.310	0.000	0.467	Current	All	186	55860	3.1664	23.7
					Current	Port	136	20271	3.3202	27.7
					Current	Trad	50	35589	3.0788	21.7
					Previous	All	404	107657	2.9668	19.4
					Previous	Port	287	42790	3.2085	24.7
					Previous	Trad	117	64867	2.8074	16.6
					Never	All	227	58874	2.9749	19.6
					Never	Port	155	19464	3.1780	24.0
					Never	Trad	72	39410	2.8745	17.7
					Unknown	All	16	3686	2.8659	17.6
					Unknown	Port	13	1638	2.5735	13.1

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Cloom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					Unknown	Trad	3	2048	3.0996	22.2
RTQ31C_B	Carpentry activity this yr	0.194	0.000	0.648	Yes	All	263	76690	3.1016	22.2
					Yes	Port	185	26825	3.2672	26.2
					Yes	Trad	78	49866	3.0126	20.3
					No	All	581	153465	2.9634	19.4
					No	Port	413	58591	3.1732	23.9
					No	Trad	168	94874	2.8338	17.0
RTQ31B_A	In-room construction this yr	0.358	0.000	0.074	Yes	All	117	34581	3.1049	22.3
					Yes	Port	77	10769	3.0730	21.6
					Yes	Trad	40	23813	3.1194	22.6
					No	All	721	195135	2.9967	20.0
					No	Port	516	74240	3.2332	25.4
					No	Trad	205	120896	2.8514	17.3
OTHCONST	Other school construction this yr	0.485	0.000	0.381	Yes	All	568	157936	3.0360	20.8
					Yes	Port	409	61681	3.2458	25.7
					Yes	Trad	159	96255	2.9015	18.2
					No	All	276	72220	2.9515	19.1
					No	Port	189	23734	3.0907	22.0
					No	Trad	87	48485	2.8834	17.9
COMPLAN	# teacher complaints in school yr	0.915	0.000	0.925	0	All	335	91495	2.9860	19.8
					0	Port	232	33620	3.1531	23.4
					0	Trad	103	57876	2.8889	18.0
					1-5	All	430	115248	3.0275	20.6
					1-5	Port	308	43361	3.2390	25.5
					1-5	Trad	122	71887	2.9000	18.2

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					>5	All	62	19744	2.9776	19.6
					>5	Port	47	7289	3.1842	24.1
					>5	Trad	15	12454	2.8567	17.4
TQ37	Overall air quality (teacher)	0.047	0.000	0.063	Excellent	All	132	36264	3.0890	22.0
					Excellent	Port	87	14035	3.3152	27.5
					Excellent	Trad	45	22229	2.9462	19.0
					Good	All	307	85306	2.8117	16.6
					Good	Port	206	28049	3.1727	23.9
					Good	Trad	101	57257	2.6349	13.9
					Adequate	All	277	75748	3.2020	24.6
					Adequate	Port	204	29544	3.2156	24.9
					Adequate	Trad	73	46204	3.1934	24.4
					Poor	All	100	26212	2.9821	19.7
					Poor	Port	78	10797	3.1267	22.8
					Poor	Trad	22	15415	2.8808	17.8
					Very_poor	All	17	4550	3.0119	20.3
					Very_poor	Port	14	1910	3.0856	21.9
					Very_poor	Trad	3	2640	2.9586	19.3
NOSESYM	Nose symptoms past 2 weeks	0.045	0.001	0.371	None	All	342	101233	3.0141	20.4
					None	Port	239	35064	3.1802	24.1
					None	Trad	103	66169	2.9261	18.7
					Occasional	All	291	76978	2.8565	17.4
					Occasional	Port	194	26192	3.1480	23.3
					Occasional	Trad	97	50786	2.7061	15.0
					Frequent	All	194	48946	3.2303	25.3

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					Frequent	Port	150	21696	3.2955	27.0
					Frequent	Trad	44	27250	3.1784	24.0
NOSESYMI	Nose symptoms at home	0.760	0.001	0.162	Same/worse	All	264	69745	2.9387	18.9
					Same/worse	Port	179	23742	3.2811	26.6
					Same/worse	Trad	85	46004	2.7620	15.8
					Improves	All	166	43426	3.1008	22.2
					Improves	Port	129	20137	3.1124	22.5
					Improves	Trad	37	23289	3.0906	22.0
					NA	All	342	101233	3.0141	20.4
					NA	Port	239	35064	3.1802	24.1
					NA	Trad	103	66169	2.9261	18.7
THRTSYM	Throat symptoms past 2 weeks	0.931	0.001	0.709	None	All	436	125701	3.0403	20.9
					None	Port	302	44338	3.2460	25.7
					None	Trad	134	81363	2.9282	18.7
					Occasional	All	250	68293	3.0025	20.1
					Occasional	Port	175	25125	3.1156	22.5
					Occasional	Trad	75	43167	2.9367	18.9
					Frequent	All	129	26844	3.0824	21.8
					Frequent	Port	99	13276	3.1886	24.3
					Frequent	Trad	30	13568	2.9785	19.7
THRTSYMI	Throat symptoms at home	0.726	0.001	0.028	Same/worse	All	167	40813	2.9406	18.9
					Same/worse	Port	117	15009	3.2706	26.3
					Same/worse	Trad	50	25804	2.7486	15.6
					Improves	All	167	42734	3.0948	22.1
					Improves	Port	128	19333	3.0124	20.3

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					Improves	Trad	39	23401	3.1629	23.6
					NA	All	436	125701	3.0403	20.9
					NA	Port	302	44338	3.2460	25.7
					NA	Trad	134	81363	2.9282	18.7
EYESSYM	Eyes symptoms past 2 weeks	0.288	0.000	0.177	None	All	458	129615	2.9940	20.0
					None	Port	320	47001	3.1709	23.8
					None	Trad	138	82614	2.8933	18.1
					Occasional	All	224	62270	3.1468	23.3
					Occasional	Port	152	20476	3.3800	29.4
					Occasional	Trad	72	41793	3.0325	20.7
					Frequent	All	121	30342	3.0778	21.7
					Frequent	Port	91	13734	3.0577	21.3
					Frequent	Trad	30	16609	3.0944	22.1
EYESSYMI	Eyes symptoms at home	0.317	0.002	0.076	Same/worse	All	158	49361	3.0758	21.7
					Same/worse	Port	101	13068	3.3978	29.9
					Same/worse	Trad	57	36293	2.9599	19.3
					Improves	All	139	34000	3.2082	24.7
					Improves	Port	108	16471	3.1376	23.0
					Improves	Trad	31	17529	3.2746	26.4
					NA	All	458	129615	2.9940	20.0
					NA	Port	320	47001	3.1709	23.8
					NA	Trad	138	82614	2.8933	18.1
CLRAGE	Classroom age (yrs)	0.432	0.094	0.291	<=10yr	All	273	44801	3.1367	23.0
					<=10yr	Port	250	32673	3.2672	26.2
					<=10yr	Trad	23	12128	2.7852	16.2

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					11-20yr	All	123	27029	3.2832	26.7
					11-20yr	Port	110	19747	3.2432	25.6
					11-20yr	Trad	13	7282	3.3915	29.7
					21-30yr	All	50	24429	2.7545	15.7
					21-30yr	Port	28	5389	2.9041	18.2
					21-30yr	Trad	22	19040	2.7121	15.1
					31-40yr	All	50	18353	3.0490	21.1
					31-40yr	Port	20	3019	3.1466	23.3
					31-40yr	Trad	30	15334	3.0298	20.7
					41+yr	All	69	39339	2.9291	18.7
					41+yr	Port	4	343	3.7142	41.0
					41+yr	Trad	65	38996	2.9222	18.6
CLRAGEX	Classroom age (yrs)	0.074	0.140	0.021	0-3yr	All	119	18008	3.1670	23.7
					0-3yr	Port	113	14176	3.3898	29.7
					0-3yr	Trad	6	3833	2.3428	10.4
					4-5yr	All	77	12024	3.4363	31.1
					4-5yr	Port	73	10438	3.4393	31.2
					4-5yr	Trad	4	1586	3.4164	30.5
					6-10yr	All	77	14768	2.8560	17.4
					6-10yr	Port	64	8059	2.8287	16.9
					6-10yr	Trad	13	6709	2.8888	18.0
					11-15yr	All	91	21006	3.3021	27.2
					11-15yr	Port	82	14911	3.2553	25.9
					11-15yr	Trad	9	6095	3.4167	30.5
					16+yr	All	201	88144	2.9254	18.6

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					16+yr	Port	80	13588	3.0859	21.9
					16+yr	Trad	121	74557	2.8961	18.1
CLRAGEU	Classroom age (known/unknown)	0.554	0.000	0.679	Known	All	565	153951	3.0383	20.9
					Known	Port	412	61172	3.2240	25.1
					Known	Trad	153	92780	2.9158	18.5
					Unknown	All	245	76204	2.9475	19.1
					Unknown	Port	162	24244	3.2075	24.7
					Unknown	Trad	83	51960	2.8261	16.9
RENOVAT	Major renovations/additions	0.351	0.000	0.722	Yes	All	233	85572	2.8897	18.0
					Yes	Port	124	20170	3.0805	21.8
					Yes	Trad	109	65402	2.8308	17.0
					No	All	535	133876	3.0737	21.6
					No	Port	421	60699	3.2498	25.8
					No	Trad	114	73177	2.9276	18.7
RENOVMAJ	Addition/wall/floor renovations	0.322	0.000	0.191	Yes	All	87	32354	2.7370	15.4
					Yes	Port	42	6191	3.2927	26.9
					Yes	Trad	45	26163	2.6055	13.5
					No	All	681	187094	3.0477	21.1
					No	Port	503	74678	3.2005	24.5
					No	Trad	178	112416	2.9463	19.0
RENOVELE	HVAC or lighting renovations	0.227	0.000	0.614	Yes	All	167	67109	2.8268	16.9
					Yes	Port	79	13864	2.9796	19.7
					Yes	Trad	88	53244	2.7871	16.2
					No	All	601	152339	3.0791	21.7
					No	Port	466	67005	3.2547	25.9

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					No	Trad	135	85335	2.9411	18.9
RENOVRUF	Roof renovations	0.250	0.000	0.164	Yes	All	92	42388	3.0520	21.2
					Yes	Port	36	7744	3.1605	23.6
					Yes	Trad	56	34644	3.0277	20.6
					No	All	676	177059	2.9900	19.9
					No	Port	509	73124	3.2125	24.8
					No	Trad	167	103935	2.8334	17.0
CLRSIZ	Classroom size (sq. ft.)	0.132	0.000	0.016	<600	All	66	20541	2.9720	19.5
					<600	Port	44	5160	2.9272	18.7
					<600	Trad	22	15381	2.9870	19.8
					600-1100	All	538	135029	3.1290	22.9
					600-1100	Port	401	60372	3.2068	24.7
					600-1100	Trad	137	74657	3.0661	21.5
					>1100	All	206	74585	2.7995	16.4
					>1100	Port	129	19883	3.3332	28.0
					>1100	Trad	77	54702	2.6055	13.5
DAMPSET	Outdoor damper min setting	0.697	0.000	0.333	<=10%	All	48	13182	3.1077	22.4
					<=10%	Port	36	6504	3.1614	23.6
					<=10%	Trad	12	6677	3.0554	21.2
					11-20%	All	122	43599	2.9112	18.4
					11-20%	Port	80	14728	3.2496	25.8
					11-20%	Trad	42	28872	2.7385	15.5
					21-40%	All	22	8033	2.8596	17.5
					21-40%	Port	16	2086	3.1958	24.4
					21-40%	Trad	6	5947	2.7417	15.5

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Cloom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					>40%	All	22	4833	3.1679	23.8
					>40%	Port	16	2106	3.3827	29.4
					>40%	Trad	6	2727	3.0019	20.1
					Unknown	All	484	126550	2.9709	19.5
					Unknown	Port	351	48665	3.1532	23.4
					Unknown	Trad	133	77885	2.8570	17.4
NEWWOOD	New pressed wood last yr	0.079	0.000	0.272	Yes	All	228	61685	3.1894	24.3
					Yes	Port	167	24777	3.3687	29.0
					Yes	Trad	61	36907	3.0689	21.5
					No	All	429	122979	2.8901	18.0
					No	Port	303	42260	3.1485	23.3
					No	Trad	126	80719	2.7548	15.7
					DK	All	81	25704	3.1182	22.6
					DK	Port	57	10719	3.1752	23.9
					DK	Trad	24	14984	3.0775	21.7
NEWCARP	New carpet past yr	0.012	0.000	0.744	Yes	All	138	29489	3.2695	26.3
					Yes	Port	108	14656	3.4504	31.5
					Yes	Trad	30	14833	3.0908	22.0
					No	All	630	189959	2.9604	19.3
					No	Port	437	66213	3.1538	23.4
					No	Trad	193	123746	2.8569	17.4
NEWFLOOR	New flooring past yr	0.040	0.000	0.438	Yes	All	183	46531	3.1991	24.5
					Yes	Port	135	18350	3.4013	30.0
					Yes	Trad	48	28181	3.0674	21.5
					No	All	441	130552	2.9980	20.0

Variable Name	Description	Adj Wald F p_Value for Variable	Adj Wald F p_Value for Room Type	Adj Wald F p_Value for Interaction	Category	Clroom Type	No. Obs	Est. Pop. Size	Est. Log-Scale Mean	Est. Geometric Mean
					No	Port	303	45538	3.2661	26.2
					No	Trad	138	85013	2.8544	17.4
					DK	All	144	42365	2.7974	16.4
					DK	Port	107	16981	2.8411	17.1
					DK	Trad	37	25384	2.7682	15.9

4. DISCUSSION

The specific objectives outlined in Section 1.2 were accomplished. Based on the response rate, sample sizes, and sampling procedures employed in this study, the data obtained can be considered representative of the target populations (after appropriate weighting) of schools, portable classrooms, and traditional classrooms. A large amount of comprehensive data was obtained making this the first major study of this type in California, if not the United States. A discussion of the general highlights resulting from the survey information is provided below.

4.1 Formaldehyde Data Quality

The quality of the formaldehyde data directly impacts the interpretation of the results of the study. The estimate of precision as measured by the median RSD of duplicate field samples of 10% was achieved for those cases where both members of the pair were detected (i.e., >6 ppb). Laboratory LODs ranged from 4 to 13 ppb, and averaged about 6 ppb. The LOD based on standard deviations of the field blanks was 12 ppb. These estimates approximate the one given in the method description provided by NIOSH. Based on these measures, the quality of the formaldehyde data resulting from this phase of the study was excellent.

4.2 Survey Response Data Quality

Response rates at the school-level were all less than 50%, as summarized below:

- 44.7% for FQ or TQ data
- 40.3% for FQ data
- 41.9% for formaldehyde monitoring data.

Although these response rates are relatively low, they are not atypical for mail surveys.

On the other hand, for the schools that responded, the conditional classroom-level response rates were good:

- 93.6% for TQ data
- 87.3% for FQ data
- 95.6% for formaldehyde monitoring data
- 82.5% for all three.

Hence, the greatest potential for bias occurs at the school level. Nonresponse bias could occur, for example, if schools with severe indoor environmental quality (IEQ) problems were less likely to participate in this study than schools without severe IEQ problems..

The combined (unconditional) classroom-level response rates range from 34.5% for all three data sets (TQ, FQ, and formaldehyde) to 41.9% for the TQ data alone.

The primary reason for relatively low response rates in Phase I of this study was the timing of the study. We started late in the school year; the first mailing to principals was on April 2, 2001. As a result, we did not go through all the usual steps, like getting superintendent approvals before contacting principals, and the schools were pressed for time because of spring breaks and end-of-year testing. A well-executed mail survey requires considerable calendar time, especially for a survey of schools or other organizations. Detailed recommendations for improving response rates are provided in Section 6.

4.3 Characterization of the Target Population of Schools

The target population of schools, an estimated 6,924 schools, is comprised of mostly suburban schools (73.8%) and mostly elementary schools (59.3%). Facility managers reported a list of common characteristics of the target schools that are identified in Section 3.3.1. A remarkable high percentage (52.1%) received some type of environmentally related complaint during the school year. The ranking of portable-classroom complaints (with percent shown in parentheses) was: Roof leaks (60.9%), Air Quality/Odor (51.2%), Temperature (50.0%), Mold (25.5%), Plumbing leaks (20.4%), and Noise (19.7). The rankings of traditional-classroom complaints were similar, although the percentages were generally lower: Roof Leaks (44.2%), Temperature (40.9%), Air Quality/Odor (31.0%), Plumbing Leaks (30.1%), Mold (16.3%), and Noise (14.8%). Many of these complaints may be interrelated, for example, noise, temperature, mold, and air quality/odor are all affected by ventilation. Such school-level comparisons can be misleading, however, due to the differences in the numbers of classrooms of the two types, and the frequencies of complaints.

Most types of environmental complaints (roof leaks, air quality/odor, mold, temperature, noise) were more prevalent for portable classrooms, especially for air quality/odor with a 20% increase. The differences in percentages between the portables and the traditional are undoubtedly related in part to the disparity in the age distributions for the two types of rooms. For example, newer construction is more likely to off-gas organic vapors (including formaldehyde) that would influence complaints about air quality and odor. Complicating the assessment of association between the age distribution of the two types of classrooms is the inherent differences in construction and operation between the two types. Further examination of the interaction between these factors will be closely examined in the Phase II monitoring study.

Temperature complaints, as reported by facility managers, are higher for portable classrooms (50%) than traditional classrooms (40%), although as the next section indicates, the teachers in portable classrooms reported that they are generally more satisfied with temperatures than teachers in traditional classrooms. Although this appears to be a contradiction, it is likely an artifact of the way the information was collected and what that information is intended to represent. As noted above, facility manager reports of complaints represent a school-wide summary over all the classrooms of a given type. However, different numbers of traditional and portable classrooms occur within schools and the frequencies of complaints may also differ by classroom type. Hence, it is more appropriate to compare the classrooms using classroom-based data rather than school-based data (see Section 4.4).

In general, there was an overall lack of awareness of "Tools for Schools" and a lack of the Integrated Pest Management (IPM) program. This suggests the need for school outreach and training to assist the schools in ways to better address environmental conditions at their school and in their classrooms.

4.4 Characterization of the Target Population of Classrooms

The target population is estimated to consist of 230,156 classrooms; 37.1% of these are estimated to be portable classrooms. Portable classrooms were more prevalent for elementary schools than for middle or high schools. A high percentage (90.4%) of the portables are devoted to general instruction, as compared to 75.1% of the traditionals. Classroom age was not known for many classrooms; however, there is a dramatic difference in the estimated age distributions for portable and traditional classrooms. For instance, 55.3% of the portables are 10 years old or less whereas only 12.4% of the traditionals are. This disparity is undoubtedly partly responsible for many other concomitant differences—e.g., structural characteristics, HVAC characteristics, and types of environmental problems/complaints. As compared to traditional classrooms, for instance, portables tend to have more carpet, more tackable wallboard, more exterior doors, more opening of windows, and more air conditioning (and thermostat control). Teachers in traditional classrooms have a strong preference for traditional classrooms over portable classrooms (84%), whereas 30% of the teachers in portable classrooms prefer their portable classrooms, and only 35% of the teachers in portable classrooms prefer traditional classrooms. Environmental problems/complaints tend to be different in the two types of classrooms (except for pest-related factors such as pesticide usage). Most such problems/complaints were more prevalent in portable classrooms, but plumbing leaks were more prevalent in traditional rooms.

4.5 Formaldehyde Levels in Portable and Traditional Classrooms

Formaldehyde is an irritant and probable human carcinogen. The ARB (1992, 1997) has identified it as a Toxic Air Contaminant, and the Office of Environmental Health Hazard Assessment (OEHHA, 2002) has listed it as a carcinogen requiring Proposition 65 warnings.

Valid indoor-air formaldehyde concentration data were obtained for 911 classrooms. For the target population (230,156 classrooms), it was estimated that only about 3% had non-detectable concentration levels (i.e., less than 6 ppb). This was true for both types of classrooms. Otherwise, some distinct differences in the distributions were evident, with the portables having higher levels.

	Portables	**Traditionals**	**All**
Mean (ppb)	32.4	23.7	27.0
Median (ppb)	27.1	20.0	22.0
90th Percentile (ppb)	57.1	42.8	50.3
% Pop. >27 ppb	50.3%	29.0%	36.9%

From the above table it can be seen that 50% of the portable classrooms are probably over the draft 8-hour indoor reference exposure level (IREL) of 27 ppb (Broadwin, 2000) for many weeks in the school year, indicating that many of the students and teachers might experience eye, nose, and throat irritation while in their classrooms. Furthermore, 4% of the portables are estimated to exceed the acute reference exposure level (REL) of 76 ppb (OEHHA, March 1999), indicating a potential risk for short-term irritation and other acute effects. In addition:

- nearly all classrooms are well above the current Chronic REL of 2.4 ppb (OEHHA) and typical annual means for outdoor air in California (3-5 ppb);
- other irritants and carcinogens may also be present in the classrooms, potentially adding to any health effects from formaldehyde;
- traditional classrooms have markedly lower formaldehyde levels than portable classrooms, even when comparing only newer classrooms, but nonetheless, nearly 30% of the traditional classrooms exceed the draft IREL (27 ppb).

It should be pointed out that the study measurements are 10-day average levels of formaldehyde, which are screening method estimates that do not directly compare to standards and guidelines based on shorter time periods. However, the measured levels of formaldehyde are probably conservative estimates of concentrations over 1 day or less, because peak short-term averages are usually higher than longer-term averages and are probably a conservative estimate of exposures over shorter time periods. The measured formaldehyde concentration levels from this study suggest the presence of significant indoor sources of formaldehyde and/or that there is inadequate ventilation with outdoor air, especially in newer portable classrooms, but also in traditional classrooms. Further analysis of these sources and the ventilation characteristics will be explored in the subsequent phase of the PCS.

A number of factors appear to be associated with formaldehyde levels in both types of rooms. The following variables showed statistically significant main effects ($p < 0.05$) in the analysis of variance (ANOVA) models that were used to identify the key factors associated with formaldehyde levels:

- Geographic region: Higher formaldehyde levels occur in the southern region, possibly due to the average higher temperatures
- Time of formaldehyde sample: Higher formaldehyde levels occur later in the school year, e.g., June/July when there are typically higher temperatures and more air-conditioning usage. (Note that the sampling period only covered the period of April through the end of the school year.)
- Overall air quality rating: There are differences between the levels of this variable, but there is not a logical pattern to them.
- Nose symptoms past 2 weeks: Higher formaldehyde levels are found in those rooms where teachers reported frequent nasal problems.
- New carpet: Higher formaldehyde levels are found in those rooms with new carpet in the past year.
- New flooring: Higher formaldehyde levels are found in those rooms with new flooring in the past year.
- New furnishing odor: Higher formaldehyde levels are observed for rooms in which new furnishing odors are present; this effect is more pronounced for the portables than for the traditional classrooms (i.e., this variable also exhibits an interaction with room type).

The last three items relate to building materials. These factors and building age probably act together as covariates and should be examined together in future data analyses. Other variables showed a significant interaction effect (with room type) in the ANOVA models. These were the following:

- Open door to outside: There is little difference in formaldehyde levels between portable and traditional classrooms for rooms with exterior doors frequently open, consistent with the notion that there would be increased outdoor air flow into the classroom, diluting formaldehyde concentration effects; when doors are infrequently opened, portables tend to have somewhat higher levels (geometric mean of 25.9 vs. 17.8 ppb for traditionals).
- Air freshener used: Portable classrooms tend to have higher formaldehyde levels than traditional classrooms in rooms where air fresheners are not used, but similar when they are used. This may be a significant indoor source of the carcinogen, paradichlorobenzene, and of organic compounds such as limonene that can react with ozone to produce indoor formaldehyde and other pollutants. Elimination of air fresheners from use in classrooms suggest a potential reduction of formaldehyde levels and possibly other organics that will be measured in the second phase of this study.
- Throat symptoms at home: A different pattern was observed for portable and traditional classrooms, but one category for traditionals had a small sample size.
- Classroom age (2nd version): Portable classrooms tend to have higher formaldehyde levels than traditional classrooms in the newest age group (0 to 3 years); for the other age groups, there is not much difference between the two types of rooms.
- Classroom size: A larger difference in formaldehyde levels between portable classrooms and traditional classrooms occurs for larger rooms (>1100 se feet). It should be pointed out that it is not intuitively obvious that formaldehyde levels would be higher in larger portable classrooms, and room size was not significant for all rooms. This suggests that activities, possibly other types of sources, and other factors such as ventilation may be accounting for this larger difference between the two classroom types. Further data analysis is warranted to try to ascertain the reasons for the differences.

Among all the ANOVA models, the room type variable, adjusted for the other variables appearing in the model, is always highly significant except for the models involving classroom age (both versions of the variable, CLRAGE and CLRAGEX). For these models the effect of room type, after adjustment, is non-significant, suggesting that at least part of the overall differences between the room types is due to the disparity in their age distributions. The sample included 250 portable classrooms 10 years old or less, but only 23 traditional classrooms in this age range. The estimated percentages of classrooms in this age range having formaldehyde concentrations above 27 ppb were 57.3% for the portables and 12.8% for the traditionals. Less difference between the room types was evident for the older age groups.

Recommendations related to these findings would involve methods to dilute the concentrations of formaldehyde resulting from indoor building materials, and indoor furnishings and sources, especially during the first 2-3 years. This could require better installation and maintenance of HVAC systems with constant fan operation especially in the early years. Steps may be required to reduce the noise of these systems while in operation so that they are not shut down during classroom use which is often the case.

Additional ANOVA models that incorporate multiple factors can be carried out in the same manner as those described above (for two factors) to examine further some of the important and interesting findings suggested by the above models.

5. SUMMARY AND CONCLUSIONS

The Phase I study involved a mail survey that was carried out in the spring of 2001 with data receipt continuing through the summer of 2001. It involved a probability sample of California public schools (and classrooms) having one or more portable classrooms. Facility managers provided school-level data (n = 384) and classroom-level data (n=1,133), via a Facilities Questionnaire (FQ). Teachers provided additional classroom level data (n = 1,181), via a Teacher Questionnaire (TQ). The classroom data were collected for three classrooms, usually two portable classrooms and one traditional classroom. For a subsample of the classrooms, air monitors were placed in the classrooms to collect indoor air samples that were analyzed to determine formaldehyde concentration levels (n = 911). This is the largest, most comprehensive study of indoor environmental quality in California public schools to date.

For the most part, the methods and materials used in the study were successful. The formaldehyde monitoring data appeared to be of acceptable quality in terms of completeness, relative precision, and sensitivity, with 97% of the measurements above the LOD. The major problem areas were the following:

- Overall response rate: Timing of the survey conflicted with the end of school year activities.
- In general, poor response rates at the school-level were achieved in the Phase I study (40 to 45%, depending on the type of data). Once having achieved cooperation at the schools, the (conditional) classroom-level response rates were good: 93.6% for TQ data, 87.3% for FQ data, 95.6% for formaldehyde monitoring data, and 82.5% for all three. Hence the combined (unconditional) classroom level response rates were 41.9% for TQ data, 39.1% for FQ data, 40.1% for formaldehyde monitoring data, and 34.5% for all three.
- Classroom identification: Teachers and facility managers were instructed regarding how to select and identify (label A, B or C) the classrooms, but this was not consistently done. This led to situations where it was difficult to identify (a) whether the two respondents were reporting on the same room, and (b) whether that room was a portable or a traditional classroom. These problems complicated the calculation of sampling weights and the merging of files.
- Questionnaire scanning: One item was inadvertently not scanned and some difficulties were encountered with others (e.g., dates). Several other questionnaire items originally designated as allowing a single response had multiple responses for a significant number of respondents. These questionnaire items had to be manually reviewed in order to enter the data.

The target population of schools, an estimated 6,924 schools, is comprised of mostly suburban schools (73.8%) and mostly elementary schools (59.3%). Facility managers reported that only about 29% of the schools were less than 30 years old, that the majority (54.4%) of the schools have 10 or fewer portable classrooms, and that over half (52.1%) of them received some type of environmentally related complaint within the year.

The target population of classrooms is estimated to consist of 230,156 classrooms; 37.1% of these are estimated to be portable classrooms. Portable classrooms were more prevalent for elementary schools than for middle or high schools. Most (90.4%) of the portable classrooms were devoted to general instruction, as compared to 75.1% of the traditionals. Classroom age was not known for many classrooms; however, there is a dramatic difference in the estimated age distributions for portable and traditional classrooms. For instance, 55.3% of the portables are 10 years old or less whereas only 12.4% of the traditionals are. This disparity is undoubtedly partly responsible for many other concomitant differences—e.g., structural characteristics, HVAC characteristics, and types of environmental problems/complaints. As compared to traditional classrooms, for instance, portables tend to have more carpet, more tackable wallboard, more exterior doors, more opening of windows, and more air conditioning (and thermostat control).

Most types of environmental complaints (roof leaks, air quality/odor, mold, temperature, noise) were more prevalent for portable classrooms; an exception was plumbing leaks, which was more common in traditional classrooms. Pest related problems seemed to be about the same in portable and traditional classrooms.

Teachers in traditional classrooms have a strong preference for traditional classrooms, whereas teachers in portables tend to be either indifferent or to favor portables.

Valid indoor-air formaldehyde concentration data were obtained for 911 classrooms. For the target population (230,156 classrooms), it was estimated that only about 3% had non-detectable concentration levels (i.e., less than 6 ppb). This was true for both types of classrooms. Otherwise, some distinct differences in the distributions were evident, with the portables having higher levels. The median concentration for portable rooms was 27.1 ppb, for instance, as compared 20.0 ppb for traditional rooms.

Analysis of variance models involving room type and one other selected variable were used to identify factors associated with formaldehyde levels and with portable versus traditional differences. Statistically significant associations were found for geographic region, time of formaldehyde sample, overall air quality rating (teacher), nasal symptoms (teacher), presence of new carpet and new flooring, and presence of new furnishing odors. Other variables showed a significant interaction effect (with room type) in the ANOVA models. These included open door to outside, classroom age, and classroom size.

Among all the ANOVA models, the room type variable, adjusted for the other variable appearing in the model, was always highly significant except for the models involving classroom age. For these models the effect of room type, after adjustment, was non-significant, suggesting that at least part of the overall difference between the room types was due to the disparity in their age distributions.

6. RECOMMENDATIONS

Recommendations that would substantially improve the quality and/or quantity of subsequent mailed surveys to California schools, include:

1. Schedule the survey to begin much earlier in the school year, and to extend across the temperature gradient experienced across the geographical regions of the state.
2. Use Dillman's "tailored design method" for designing and implementing mail and internet surveys (Dillman, 2000).
3. Pre-arrange all school related material so that each form has the school and classroom identifier so that teachers and facility managers would not be able to mis-identify the classroom. This may require that someone select the classrooms before shipping the materials.
4. Allow more time for survey instrument development, testing and electronic processing so that all details will be worked out prior to implementation.
5. Consider use of web-based information collection and transfer to take better advantage of emerging technologies. This should include instructional materials (videos), on-line messaging, and verification checks of information transfer.

If California were to implement a similar survey in the future, we recommend that the survey begin early in the school year and that procedures more like those used for Phase II of this study be implemented in Phase I, also. In particular, we expect that implementing the following procedures would significantly improve response rates relative to those experienced in Phase I:

- Obtain written approval from the district superintendents before mailing anything to the school principals. Provide a template for superintendents to sign and date. Have them mail or fax the signed permission forms to the survey contractor to make it quick and easy for the superintendent to provide his/her written approval.
- Include a copy of the superintendent's signed permission form prominently in the package(s) mailed to the principals. Several principals told us that they discard all requests to participate in research studies that have not been approved by their superintendent.
- Telephone the schools to obtain their site plan or list of classrooms and select the sample classrooms for them, rather than asking the schools to select the sample classrooms themselves. Although cookbook-type instructions were used in Phase I and the sampling process was very simple, many study coordinators had difficulty understanding and correctly implementing the process because of a lack of time to carefully read and follow the instructions.
- Follow-up all nonrespondents with additional mailings and telephone contacts to prompt the schools to complete their data collection.
- Collect data from reluctant respondents by telephone to increase response rates.
- Consider using more robust push-pins or another more robust method of attaching the formaldehyde monitoring tubes to the ceiling to reduce loss due to breakage.
- Further clarify the instructions regarding use of the formaldehyde monitoring tubes to ensure that QC samples are collected correctly, that times and dates are recorded for all samples, and that all tubes are properly sealed before shipment to the lab. Schools

often failed to report the dates and times that tubes were hung and retrieved. This should be emphasized on the study coordinator's checklist and should be discussed with the study coordinator after the sample classrooms have been identified.

Above and beyond these specific steps, applying the following general principles, to the extent possible, also would enhance response rates:

- Use several contacts. The number of repeated contacts has consistently been shown to be directly related to the final response rate (see Dillman, 2000, pg. 149). Hence, reminder postcards and nonresponse follow-up by mail, email, and telephone can make an important difference in the final response rates.
- Use personalized addresses on envelopes and in the salutations of letters. This recommendation may be difficult to implement because the most current California Public Schools Directory is usually one year out-of-date, and the turnover of school staff from year to year is not negligible.
- Use participant incentives so that participating schools and districts receive some direct reward or token of appreciation for their participation. The incentives may be cash, school supplies, books, and/or reports of the study findings, both for the individual school and for the study as a whole. Incentives have consistently been shown to improve response rates.

Another alternative that might improve both the response rates and the timeliness of the study would be to use Web-based data collection instruments, instead of mail questionnaires. Quality checks could be built into the Web-based instruments and email could be used to prompt nonrespondents. However, a pilot test would be needed to determine whether or not teachers and facility managers would be willing to take the initiative to log on to a data collection site and complete their surveys.

Recommendations from the formaldehyde laboratory (Air Quality Research) for improving the quality of the formaldehyde data are provided in Appendix H.

Recommendations from ARB and DHS for reducing formaldehyde levels in schools are provided in Appendix I.

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